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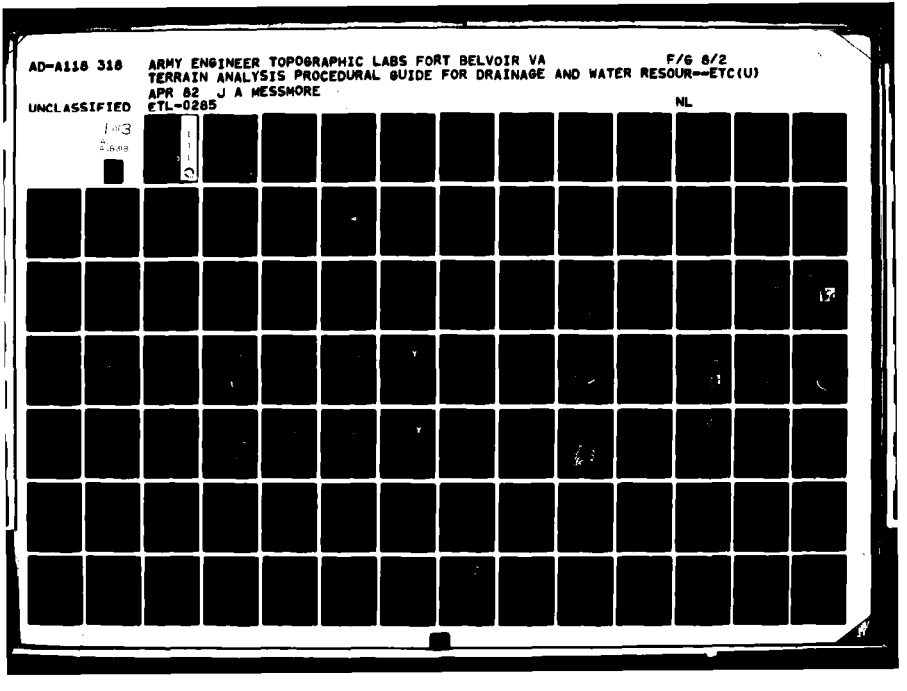

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Terrain analysis procedural guide for drainage and water resources

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Jeffrey A. Messmore

APRIL 1982

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This document is one in a series of terrain analysis procedural guides being developed in support of the Topographic Support System (TSS). It was written specifically for the U.S. Army's Terrain Analysts and presents the methodology for extracting, reducing, and recording information for the drainage and water resources data field. This data field is divided into 3 subfields: (1) watercourses and water bodies, (2) drainage basins, and (3) ground water. Step-by-step procedures are provided for producing a factor overlay and supporting data tables for each of the drainage and water resources data fields.

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PREFACE

This guide for Drainage and Water Resources is one of a series of Analysis and Synthesis Guides to be produced. After some modifications, the guides will be published as Department of Army manuals. For this reason, critical comments and suggestions are requested by the author.

The published guides in this series are

Number	Authors	Title	AD Number
ETL-0178	Jeffrey A. Messmore Theodore C. Vogel Alexander R. Pearson	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR VEGETATION (Report No. 1 in the ETL Series on Guides for Army Terrain Analysts)	AD-A068 715
ETL-0205	Theodore C. Vogel	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR ROADS AND RELATED STRUCTURES (Report No. 2...)	AD-A080 021
ETL-0207	James Tazelaar	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR GEOLOGY (Report No. 3...)	AD-A080 064
ETL-0220	Alexander R. Pearson Janet S. Wright	SYNTHESIS GUIDE FOR CROSS-COUNTRY MOVEMENT (Report No. 4...)	AD-A084 007
ETL-0247	Roland J. Frodigh	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR CLIMATE (Report No. 5...)	AD-A095 158
ETL-0254	Janet S. Wright Theodore C. Vogel Alexander R. Pearson Jeffrey A. Messmore	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR SOIL (Report No. 6...)	AD-A107 048
ETL-0263	James Tazelaar	SYNTHESIS GUIDE FOR LINES OF COMMUNICATION (Report No. 7...)	AD-A104 208

This study was conducted under DA Project 4A762707A855, Task C, Work Unit 21, "Military Geographic Analysis Technology."

This study was done under the supervision of A. C. Elser, Chief, MGI Data Processing and Products Division; and K. T. Yoritomo, Director, Geographic Sciences Laboratory.

Colonels Daniel L. Lycan and Edward K. Wintz were Commanders and Directors and Mr. Robert P. Macchia was Technical Director of the Engineer Topographic Laboratories during this study and report preparation.

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI)
UNIT OF MEASUREMENT

U.S. Customary Units of Measurement used in this report can be converted to metric (SI) as follows:

MULTIPLY	BY	To Obtain
inches	25.4	millimeter
feet	30.48	centimeter
miles	0.6093	kilometer
acres	0.405	hectare
ounces	28.57	gram
gallons	3.785	liter
Fahrenheit degrees*	5/9	Celsius degrees, Kelvin

*To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula:

$$C = (5/9)\ (F-32)$$

To obtain Kelvin (K) readings, use formula:

$$K = (5/9)\ (F-32) + 273.15$$

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TERRAIN ANALYSIS PROCEDURAL GUIDE
FOR DRAINAGE AND WATER RESOURCES

1. INTRODUCTION

1.1 Purpose. The purpose of this guide is to provide the Army's terrain analysts with step-by-step procedures for extracting, reducing, and recording drainage and water resource information. The principal information sources treated in this guide include topographic maps, literature, and aerial photography.

1.2 Background. The first step in generating terrain intelligence and preparing special purpose products is to reduce the data contained in a variety of source materials to a uniform format. This first step of extracting data from available sources, then reducing and recording it in the desired form, is the most laborious and time-consuming step in the production cycle. If the process is delayed until a production requirement is imposed, the response time would be increased. However, if the extracting, reducing, and recording is performed in advance and the preformatted results maintained in the data base, the time required to respond to a production requirement can be greatly reduced. One practical method of producing this information is the factor overlay concept, which records the results of the terrain analysis for the data base.

In figure 1.1, the factor overlay concept for preformatting data is shown in the form of factor overlays registered to standard military topographic maps. Under this concept, data are extracted from various source materials and recorded on factor overlays and supporting data tables. Separate overlays and tables are prepared for each map sheet for each major terrain subject or data field, e.g. soil, climate, vegetation, and roads. Factor overlays and tables are intermediate data base products intended primarily as tools for the terrain analyst and are not customarily distributed outside of the topographic and intelligence communities.

Factor overlays are used in various combinations to generate factor-complex maps that become, in effect, the manuscripts for special purpose products, such as cross-country movement, lines of communication, IPB (Intelligence Preparation of the Battlefield) graphics, etc. The data elements appearing on complex maps become inputs for analytical performance prediction models. For example, preparing a cross-country movement (CCM) map would begin by combining the overlays for slope, soil, and vegetation into a complex map. Those data elements affecting CCM, i.e. percent slope, stem spacing, stem diameter, soil strength, etc., are then recorded in the complexed areas of the map. When processed by analytical models, these elements are transformed into vehicle speed predictions for each complexed area.

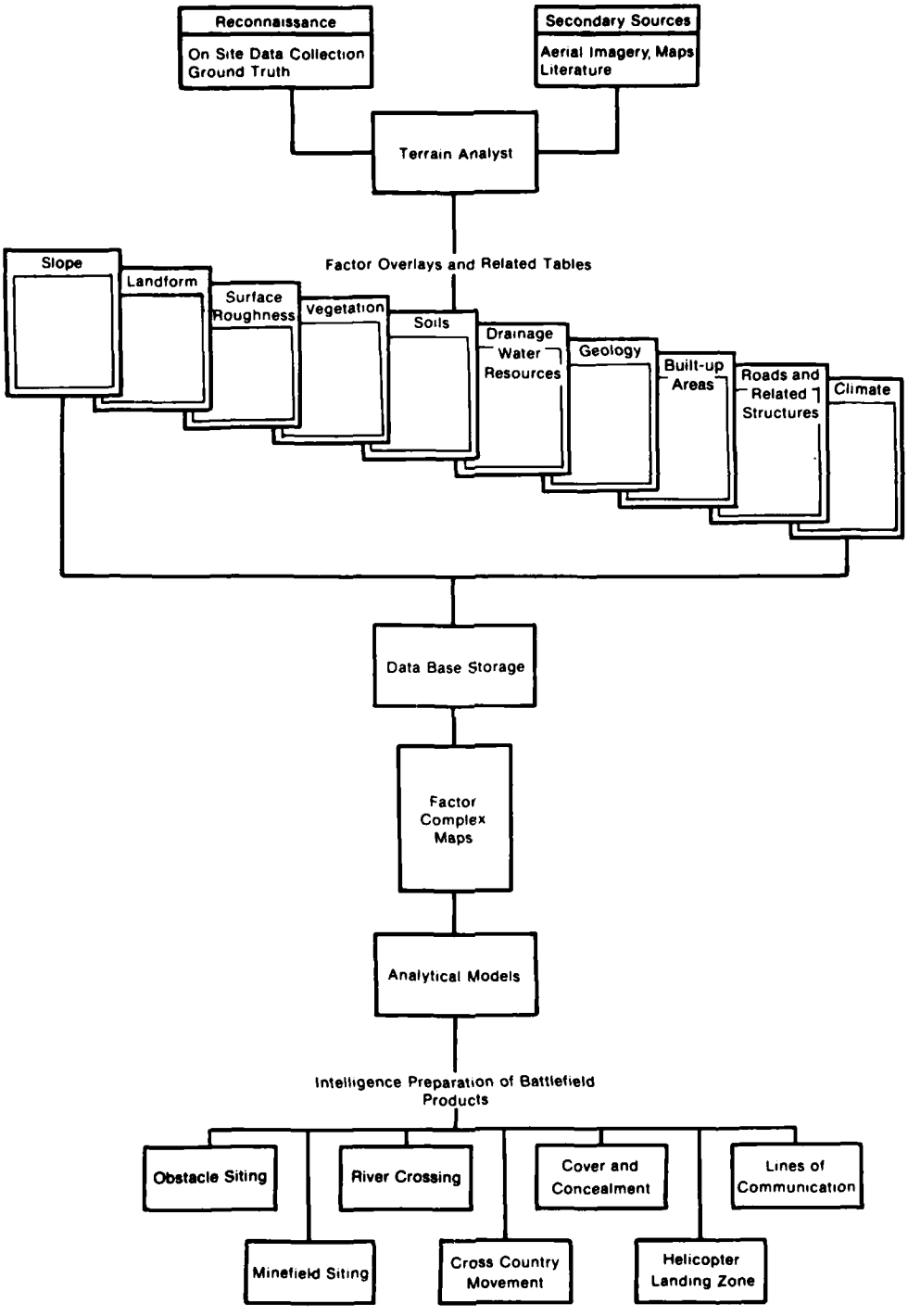


Figure 1.1 Production and Use of Factor Overlays and Data Tables.

1.3 Drainage and Water Resources Data Fields. The drainage and water resources data field consists of three sets of factor overlays, each with accompanying data tables as outlined below:

A 1:50,000 scale watercourse and water body factor overlay with three data tables that provide information on surface water.

A 1:50,000 scale drainage basin factor overlay with three data tables that provide information primarily on physical dimensions of basins.

A 1:50,000 scale ground water factor overlay with two data tables that provide information on ground water.

Before proceeding to a more detailed discussion of each of the data fields, it must be emphasized that it is very unlikely the analyst will be able to fulfill all of the data field requirements for a particular map area during the initial generation of an overlay. Rather, generation of the drainage and water resources data base is a cumulative procedure with information added as it is obtained.

1.3.1 Watercourses and Water Bodies.

Rivers, streams, brooks, and creeks are some of the terms used to describe water that flows over the earth. Owing to the problem of defining these terms with physically measurable quantities, e.g. width, depth, discharge, etc., none of these terms receive great emphasis in this guide. Instead, surface-flowing waters, without regard to size, are referred to as watercourses. For standing bodies of water, many terms such as lakes, ponds, and reservoirs could be applied to these bodies. However, to standardize this nomenclature, these standing bodies of water are referred to as water bodies in this guide.

Both watercourses and water bodies can be of great importance to the Army field commander. He must have access to up-to-date surface water data so that he can effectively use the resources available to him. Most of this information is located in the watercourse and water body data field that contains information called data elements. These elements include watercourse widths and alinements, bank slopes and heights, hydrologic structure locations, and other data. It is the terrain analyst's responsibility to derive and then record this information either on the factor overlay (figure 1.2) or in one of the data tables (figures 1.3-1.5). Review the data element information below and note which elements are included on the factor overlay and which are included in the data tables.

1.3.1.1 Watercourses and Water Bodies Data Elements.

a. Factor Overlay

(1) Alinement of all watercourses.

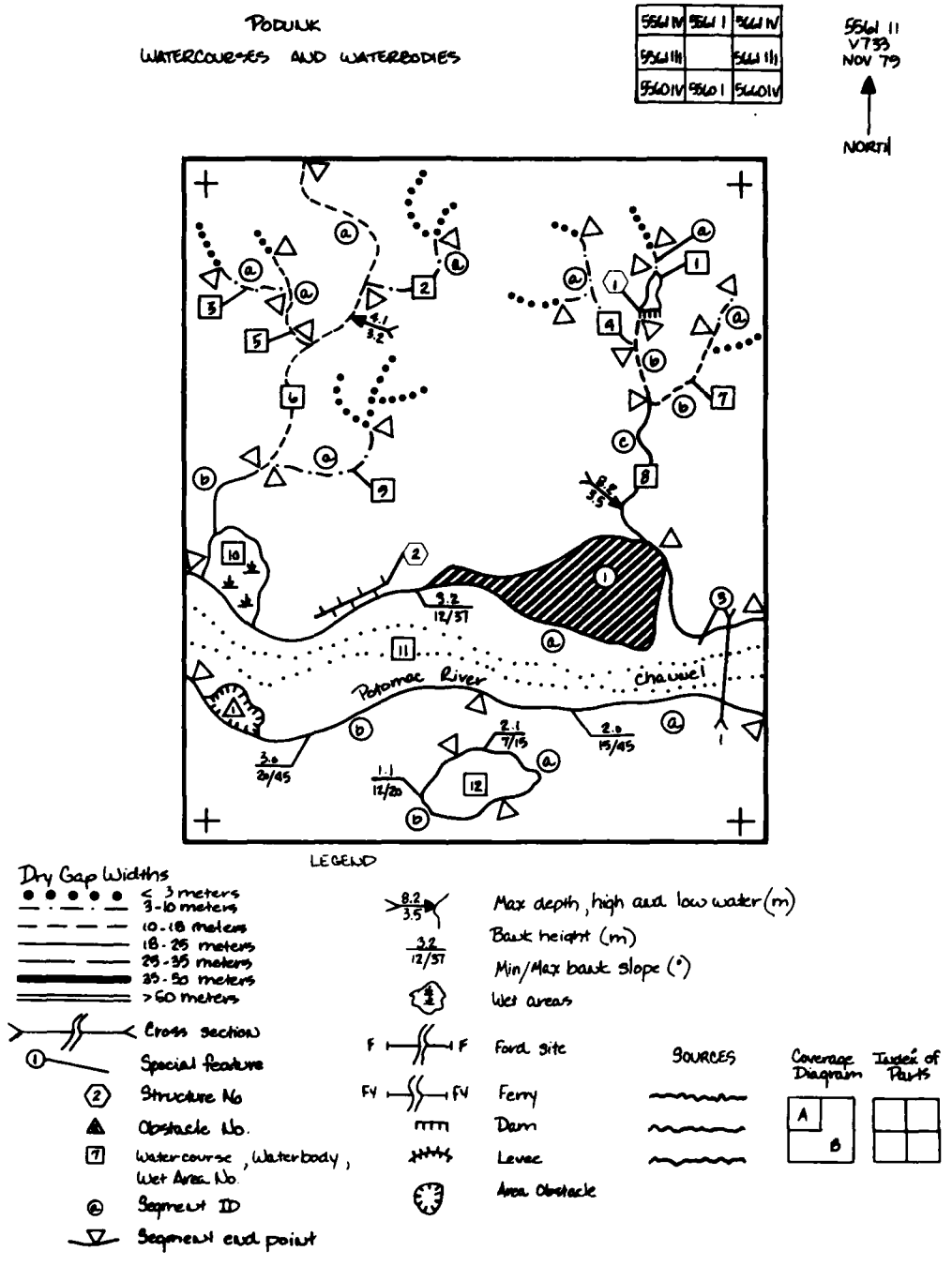


Figure 1.2 Format for Watercourse and Water Body Factor Overlay.

SCALE OF BASE MAP 1:50,000
USAETL

DATA TABLE 1 - WATERCOURSES AND WATERBODIES

5561 IV	5561 I	5561 IV
5561 III		5561 III
5560 IV	5560 I	5560 III

5561 11
V733
NOV 79

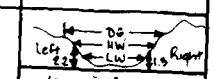
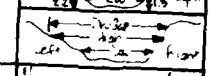
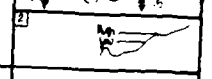
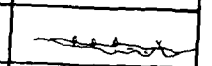
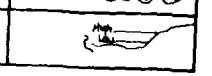
HYDROGRAPHIC FEATURE				DRY GAP WIDTH IN METERS	SEASONAL DEPTH WIDTH AND VELOCITY INFORMATION										BANK INFORMATION						MAX DISCHARGE cu m/s	CROSS SECTION SKETCH
					HIGH WATER CONDITIONS					LOW WATER CONDITIONS					RIGHT BANK			LEFT BANK				
ID NO	LOCAL NAME	CLASS	SEG LETTER		MONTH(S)	DEPTH (m) MIN	DEPTH (m) MAX	WATER WIDTH IN METERS	VEL mps	MONTH(S)	DEPTH (m) MIN	DEPTH (m) MAX	WATER WIDTH IN METERS	VEL mps	HEIGHT IN METERS	SLOPE IN DEGREES MIN/MAX	MATERIAL	HEIGHT IN METERS	SLOPE IN DEGREES MIN/MAX	MATERIAL		
1	Pohick Creek	Stream	a	8.1	Mar	2.2	2.7	6.2	2.1	Aug	1.7	2.3	3.1	0.5	2.0	15/31	GC-GM	1.5	10/32	Gw.GP	740	
			b	12.4	Mar	3.0	4.1	6.5	2.3	Aug	2.0	3.1	3.3	0.5	3.0	13/19	CM Stone	2.0	5/20	SMCL	740	
2	Potomac River	River	a	2500.0	Jan; Feb	20	22	2200	20	Oct	25	17	2100	1.0	4.0	25/60	Rock	—	—	—	1500	
			a	2500.0	Jan; Feb	18		2400	20	Oct	20		2200	1.0	—	—	—	2.0	15/45	SC	1500	
			b	2600.0	Jan; Feb	25	29	2400	20	Oct	20	24	2250	1.0	—	—	—	3.0	20/45	SC	1500	
3	Great Swamp	Swamp	—	—	Apr	1.0	1.2	—	—	Sept	0.5	Dry	—	—	—	—	—	—	—	—	—	
4	Walden Pond	Pond	a	20.0	Apr	2.0	2.8	15	<1	Sept	1.0	1.5	12	<1	1.0	15/40	CM	—	—	—	—	

Figure 1.3 Format for Data Table 1 – Watercourses and Water Bodies.

DATA TABLE 2 - WATERCOURSES AND WATERBODIES

HYDROGRAPHIC FEATURE				BOTTOM CONDITIONS		TIDAL INFLUENCE			WATER QUALITY					ICE CONDITIONS													OBSTACLES	
														NO OF ICE DAYS PER MONTH												MAX ICE THICKNESS (cm)		
ID NO	LOCAL NAME	CLASS	SEG NO	MATERIAL	SLOPE IN DEGREES	MAX MO'S	MIN MO'S	DAILY RANGE IN METERS	ID NO	SAMPLE DATE	ANALYSIS CHEM	ANALYSIS ppm(mg/l	GEN CLASS	1	2	3	4	5	6	7	8	9	10	11	12		ID NO	DESCRIPTION/SKETCH
1	Pohick Creek	Stream	a	CL SOME BOULDERS	30	3,8	6,12	0 2	1	10-71	Ca Mg Na Bic Cl	44 12 65 17 70	Brackish Polluted	6	8	5	-	-	-	-	-	-	-	2	2	30	1	Wind Fall Trees
			b	CM SOME BOULDERS	30	3,8	6,12	0 3	2	1-72	F Na Cl	15 60 110	Brackish Polluted	6	8	5	-	-	-	-	-	-	-	2	2	20		
2	Potomac River	River	a	CL overCS	2	3,8	6,12	0 5	3	10-76	Ca F Cl	60 10 90	Brackish	5	6	-	-	-	-	-	-	-	-	1		20	3	Sunken Barge 4x10x3 Meters at 1345 9126
			a																									
			b	CL over Rock	2	3,8	6,12	0 5	-	—	-	—	Brackish	5	6	-	-	-	-	-	-	-	-	-	-	20	4	Submerged Rocks
3	Great Swamp	Swamp		DH PT OVER CL	<1	3,8	6,12	0.2	5	1-72	—	—	High Coliform Count	7	9	6	-	-	-	-	-	-	-	-	-	30	-	None
4	Walden Pond	Pond	a	CM	<1	—	—	—	4	12-72	NaCl Cacl Cl F	16 110 200 20	Fresh	7	9	6	-	-	-	-	-	-	-	-	-	30	-	Reeds Near Shore

Figure 1.4 Format for Data Table 2 – Watercourses and Water Bodies.

DATA TABLE 3 - WATERCOURSES AND WATERBODIES

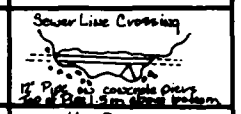
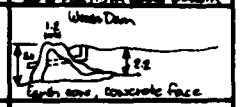
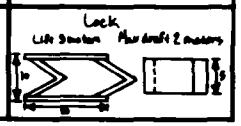
HYDROGRAPHIC FEATURE				NAVIGATION INFORMATION											AREAS SUBJECT TO FLOODING					STRUCTURES & SPECIAL FEATURES	
				NAVIGATION SEASON			CLEARANCES														
							MIN VERTICAL IN METERS			MIN HORIZONTAL IN METERS			MAX DRAFT IN METERS								
ID NO	LOCAL NAME	CLASS	SEG NO	OPEN DATE MO/DAY	CLOSE DATE MO/DAY	CAUSE	UTM COORD	LOW W	HIGH W	UTM COORD	LOW W	HIGH W	LOW W	HIGH W	ID NO	LAST DATE	MEAN DEPTH	DURATION (DAYS)	CAUSE	ID NO	DESCRIPTION/SKETCH
1	Pohick Creek	Stream	a	—	—	—	—	—	—	—	—	—	—	—	1	6/72	2.0	3	Heavy Rains	1	
			b	2/15	12/20	Ice	82264018	410	210	82264018	5.0	5.0	0.5	1.5			None	on [illegible]		2	
2	Potomac River	River	a, b, c, d, e	2/1	12/20	Low Water	92263017	5.0	3.1	92263017	1000	1000	5.0	7.0	2	6/72	3.0	6	Ice Jam	4	Numerous Small Boat Docks
																				6	

Figure 1.5 Format for Data Table 3 – Watercourses and Water Bodies.

(2) Shore alinement of all water bodies.

(3) Terminal points and identification of watercourses with dry gap widths 3 meters (m) or greater.

(4) Terminal points and identification of watercourse segments with dry gap widths 3 meters (m) or greater.

(5) Dry gap widths, by classes, of watercourses with gap widths 3 meters (m) or greater.

(6) Average maximum depth during seasonal high and low water periods.

(7) Bank heights and minimum/maximum slopes above mean water for watercourses with gap widths greater than 50 m.

(8) Delineation of wet areas.

(9) Structures and special features/areas.

(10) Point and area obstacles.

(11) Areas subject to flooding.

(12) Location of watercourse cross sections.

(13) Navigation channels.

(14) Location of fords and ferries.

b. Data Tables

(1) Classification of watercourses, water bodies, and wet areas.

(2) Wet and dry gap widths.

(3) High and low water conditions.

(4) Water velocity and maximum discharge.

(5) Bank and bottom information.

(6) Representative watercourse cross sections.

(7) Tidal influence.

(8) Water quality information.

(9) Ice conditions.

(10) Description/sketch of point and area obstacles.

(11) Navigation information.

(12) Description of areas subject to flooding.

(13) Description/sketch of hydrologic structures and special features/areas.

1.3.2 Drainage Basins.

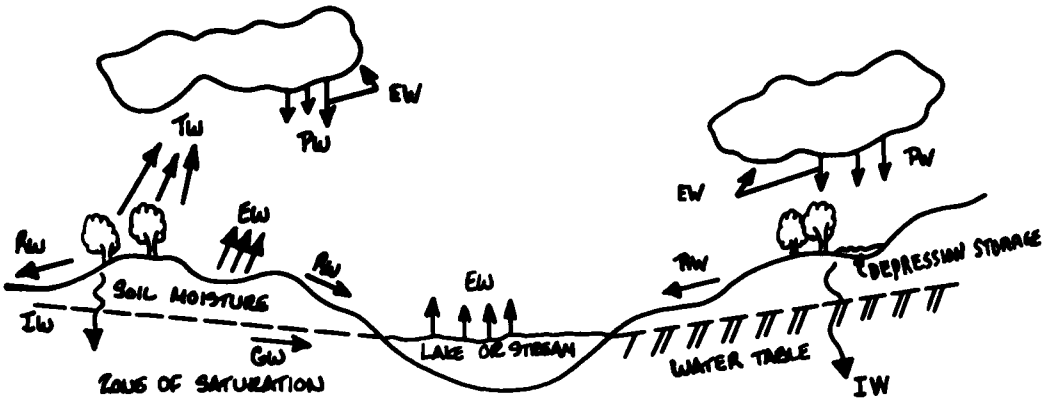
Watersheds, drainage basins, and catchment basins are terms often used interchangeably to describe the terrain from which a lake, river, or stream receives water. The size of these terrain features varies greatly, ranging from an area as small as 1 hectare (10,000 m^2) to an area encompassing thousands of hectares. The Mississippi River basin, for example, is composed of many smaller basins that when added together include most of the central portion of the United States. However, the tactical commander is rarely concerned with the hydrologic characteristics of drainage basins of such large dimensions, but rather he is primarily interested in the characteristics of basins located in 1 or 2 Corps-sized areas (approximately 1,000 km^2).

Each drainage basin responds to precipitation in a unique manner that is controlled by the hydrologic characteristics of the basin. The terrain analysts' responsibility is to determine some of these essential basin characteristics and then to record them on the overlay and in the data tables. This basic information, when used in conjunction with more detailed information, can then be used to answer important questions, for example, how long does it take for rainfall of a given intensity to cause an increase in discharge at a point downstream? The answer to these questions can have great influence on the planning of tactical operations.

1.3.2.1 The Hydrologic Budget.

Because the total quantity of water available to the earth is indestructable and limited, the total global hydrologic budget can be looked upon as a closed, cyclical system (figure 1.6). Although the world's budget can be thought of as a closed system, each individual drainage basin is an open system. This is because a considerable amount of the precipitation that falls within the boundaries of the basin is lost through factors such as surface runoff, evaporation, and infiltration (figure 1.7).

The basin characteristics that must be described or physically measured to understand the hydrologic behavior of each basin



RW = SURFACE RUNOFF WATER
IW = INFILTRATED WATER
GW = GROUND WATER
PW = PRECIPITATED WATER
EW = EVAPORATED WATER
TW = TRANSPIRED WATER

Figure 1.6 Hydrologic Budget.

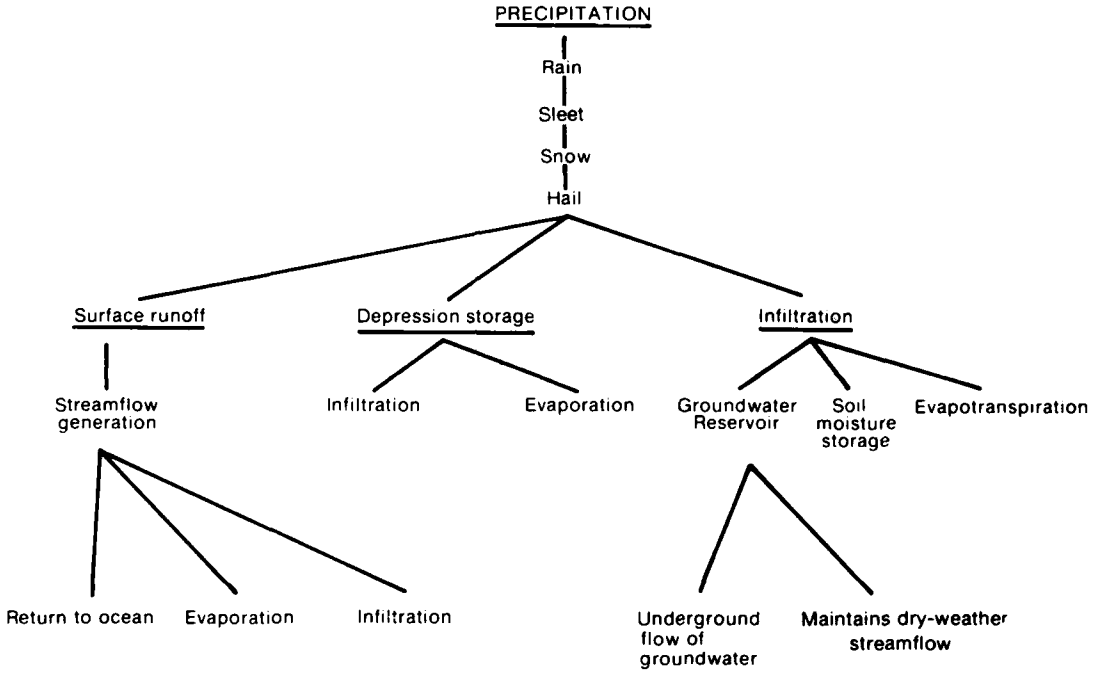


Figure 1.7 Schematic of Hydrologic Budget.

are called data elements. The terrain analyst must fulfill the data requirements for each element by extracting information from topographic maps, aerial photos, and technical literature. This data element information is then recorded on the drainage basin factor overlay (figure 1.8) or in one of the three data tables (figure 1.9). Review the data element information given below and note which data elements are included on the factor overlay and which are included in the data tables.

1.3.2.2 Drainage Basin Data Elements.

a. Factor Overlay

(1) Alinement of all watercourses.

(2) Delineation of the boundaries of primary, secondary, and tertiary drainage basins.

(3) Letter identification of each primary and secondary drainage basin.

(4) Alphanumeric identification of each tertiary drainage basin.

b. Data Table 4. Primary Drainage Basins

(1) Identification symbol (single letter) and name of primary drainage basin.

(2) Name(s) of political unit(s) located within the basin's boundaries.

(3) Total surface area of the drainage basin (hectares).

(4) Length of primary basin channel (km).

(5) Type and location (UTM coordinates) of hydrologic structures.

(6) Number of secondary drainage basins.

(7) Number of tertiary drainage basins.

c. Data Table 5. Secondary Drainage Basins

(1) Identification symbol (double letter) and name of secondary drainage basin.

(2) Total surface area of the drainage basin (hectares).

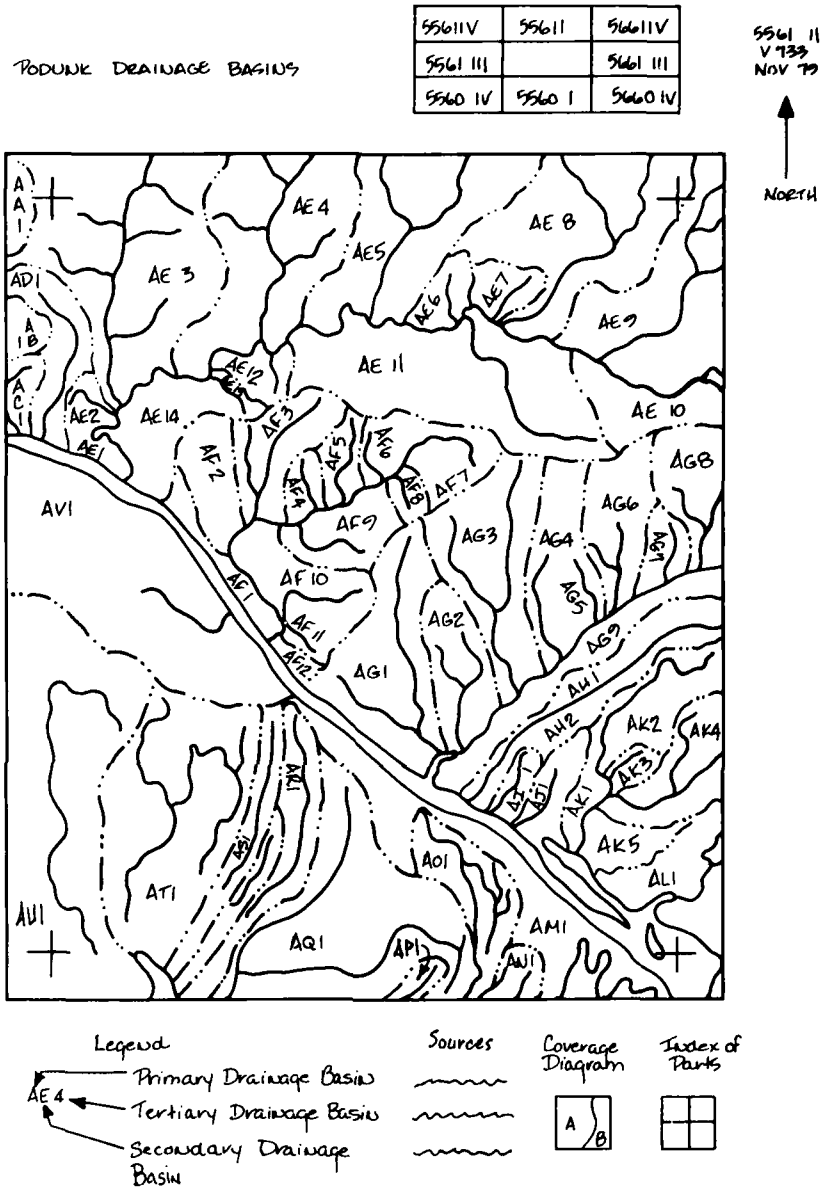


Figure 1.8 Format for Drainage Basin Factor Overlay.

DATA TABLE 4 - PRIMARY DRAINAGE BASINS

1	2	3	4	5	6	7	8	9
ID	Name	Political Unit(s)	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures		No of Secondary Drainage Basins	No of Tertiary Drainage Basins
					Type	UTM Coord		
A	Susquehanna River	Moore Co	56 3	6 2	Concrete Dam	9226317	2	5

DATA TABLE 5 - SECONDARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures	
				Type	UTM Coord.
AA	Swatara Creek	19 1	2.1	None	
AB	Wilson Creek	37 4	3.1	See Table 4	

DATA TABLE 6 - TERTIARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures	
				Type	UTM Coord.
AA 1	Smith Creek	12.2	1 1	None	
AA 2	Salmon Creek	7.3	0.4	None	
AB 1	Shell Creek	17.5	1.6	See Table 4	
AB 2	Red Creek	5.2	0.3	None	
AB 3	Mill Creek	15.1	2.1	None	

Figure 1.9 Format for Drainage Basin Data Tables.

(3) Length of secondary basin channel (km)

(4) Type and location (UTM coordinates) of hydrologic structures not recorded in Data Table 4.

d. Data Table 6. Tertiary Drainage Basins

(1) Identification symbol (letter and number) and name of tertiary drainage basin.

(2) Total surface area of the drainage basin (hectares).

(3) Length of tertiary basin channel (km).

(4) Type and location (UTM coordinates) of hydrologic structures not recorded in Data Tables 4 or 5.

1.3.3 Drainage Basins.

In addition to the surface water and water vapor components of the hydrologic budget, another important component, ground water, is found in the saturated zone beneath the earth's surface (see figure 1.6). Only a fraction of the rain water that falls on a drainage basin flows out in the basin's network of watercourses. Some of the water evaporates, some is used by vegetation, and some seeps into the ground. The latter process is an origin of ground water.

As shown in figure 1.6, the ground water surface (water table) is a reflection of the surface topography, but with less relief. In areas where water bodies and wet areas occur, the water table can be expected to be continuous with the surface of these features. When such features are absent or widely spaced, the water table's elevation must be determined from measurements, such as those taken from observation wells. If the water table is exposed, as on a valley slope, a rock fracture map produce a spring. This water source may be active throughout the year or for only a portion of it, depending upon the degree of seasonal fluctuation in the water table.

Ground water can be an important source of fresh water, especially in dry areas, and for this reason, the analyst must accumulate data on this component of the hydrologic budget. Listed below are the data elements associated with the ground water data field. Review this information and note which elements are included on the factor overlay (figures 1.10 and 1.11) and which are included in the data tables (figure 1.12).

1.3.3.1 Ground Water Data Elements

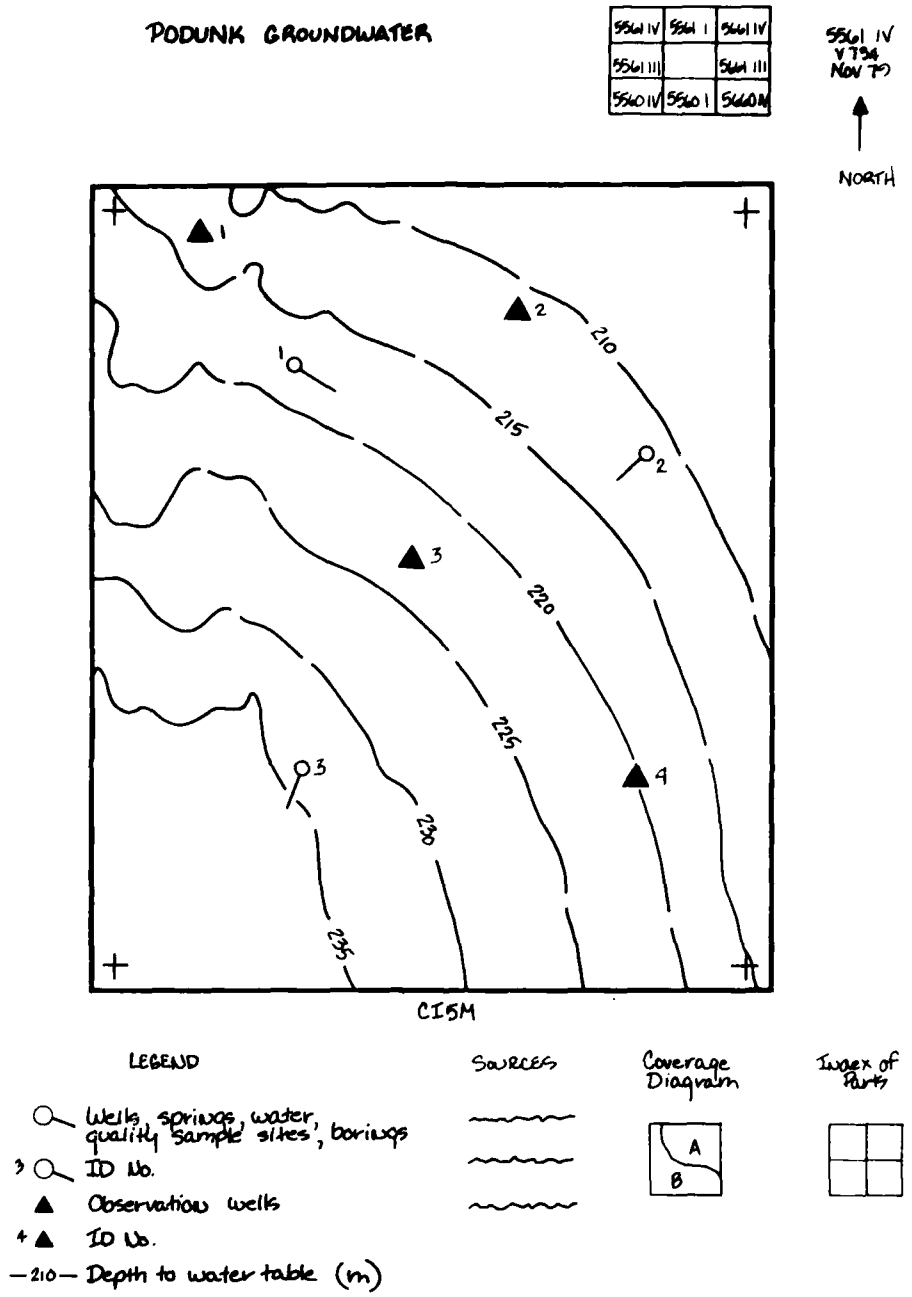
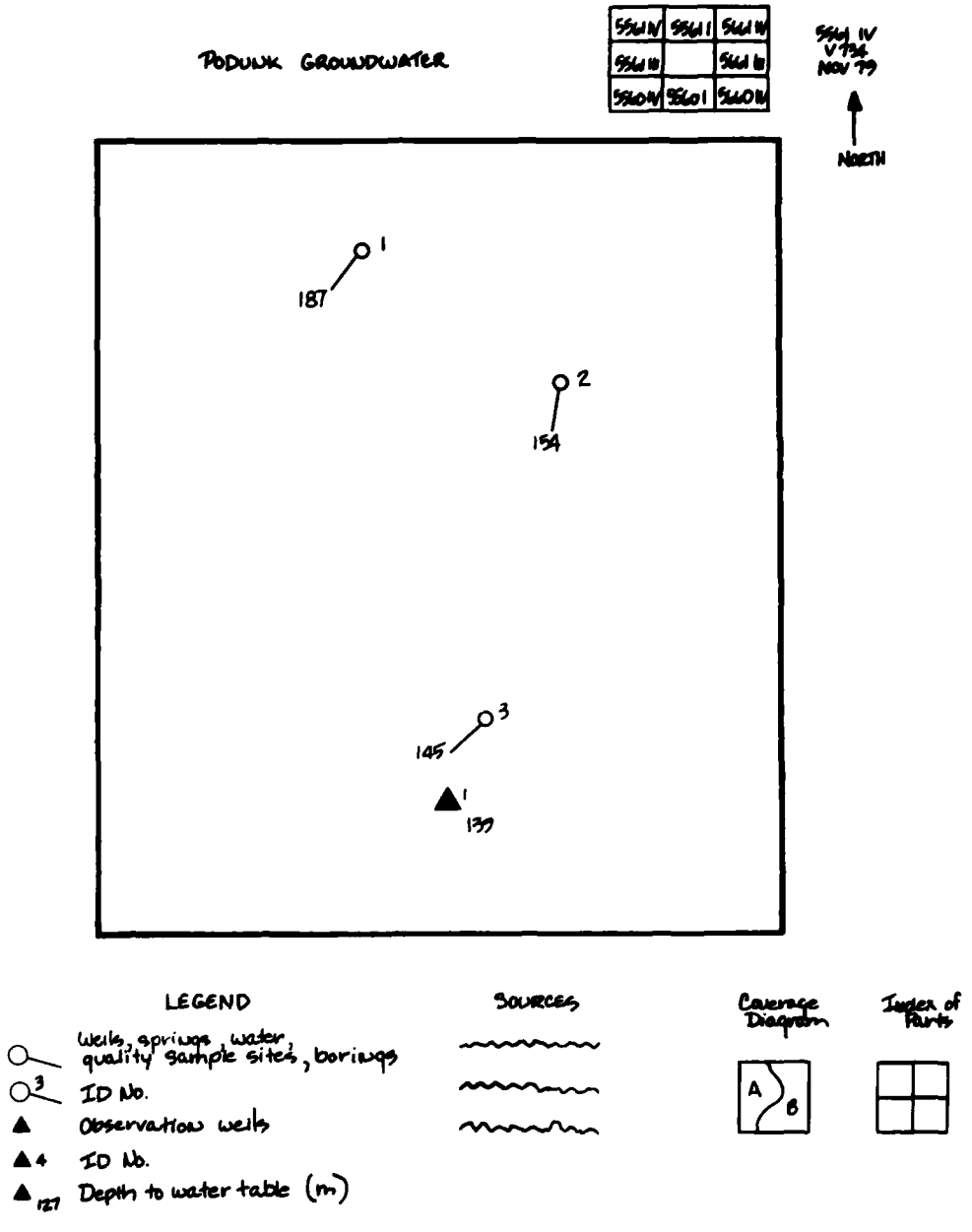


Figure 1.10 Format for Ground Water Factor Overlay.



Note. This format is used when there is an insufficient number of known ground water levels to construct a contour map.

Figure 1.11 Alternate Format for Ground Water Factor Overlay.

DATA TABLE 7 - WELLS AND SPRINGS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ID No	Type	Name	UTM Coordinates	Yield (gpm)	Date Measured	Specific Capacity (gpm/ft drawdown)	Diameter (cm)	Well Depth (m)	Depth to water (m)	Land Surface Datum above Mean Sea Level (m)	Top of Well above lsd (m)	Water Quality					Remarks
												Component	Units	Min	Max	Mean	
1	Spring	Unnamed	9650427 1	72	3/75	N/A	—	—	—	—	—	Temp Ca Mg pH Nitrate Dissolved Solids	°C mg/L mg/L units mg/L mg/L	12 48 9 7.0 0.1 148	18 384 179 7.8 15 1949	16 63 32 7.5 0.7 862	Flows yearround except during driest years.
2	Well	Unnamed	9650493 4	90	Estimated	Unknown	15	118	52	69.7	1.5	No data					Source of irrigation water
3	Well	Unnamed	9651482 7	—	—	—	15	227	—	—	—	Temp Iron Mn CO_3 Nitrate	°C mg/L mg/L mg/L mg/L	— — — — —	— — — — —	16 380 210 0 .23	Water quality sample site

DATA TABLE 8 OBSERVATION WELLS

1	2	3	4	5	6	7	8	9	10	11
ID No	UTM Coordinates	Diameter (cm)	Well Depth (m)	Highest (m)	Date	Lowest (m)	Date	Mean (m)	Land Surface Datum above Mean Sea Level (m)	Top of Well above lsd (m)
1	9650426 5	8	192	2.3	3/75	10.5	9/64	6.2	230	1.2
2	9650429 5	15	70	3.1	4/70	11.2	10/71	7.6	202	0.9

Figure 1.12 Format for Ground Water Data Tables.

a. Factor Overlay

(1) Location of wells and springs.

(2) Location of observation wells.

(3) Location of water quality sample sites.

(4) Contour map of gound water surface (if sufficient number of ground water levels are known).

b. Data Table 7. Wells and Springs

(1) I.D. numbers and UTM coordinates of all wells, springs and water quality sample sites.

(2) Yield, gallons per minute (gpm), of wells and springs and date measured.

(3) Specific capacity (gpm/ft. drawdown) of wells.

(4) Well dimensions and depth to water.

(5) Water quality information.

(6) Remarks.

c. Data Table 8. Observation Wells

(1) I.D. numbers and UTM coordinates of all observation wells.

(2) Well dimensions.

(3) Depth-to-water table information.

(4) Land surface datum (l.s.d.) above mean sea level (m.s.l.).

2. SOURCE MATERIALS

2.1 Watercourses and Water Bodies

No one source can provide the comprehensive data required to complete the watercourses and water bodies factor overlay and data tables. However, one source that is very useful is large-scale topographic maps, particularly to obtain watercourse and water body shore alinement. This source can also be used for position information (UTM

coordinates).

Vertical aerial photography, especially that of 1:20,000, or larger scale, is also a very valuable source of information. It can be used to determine watercourse and water body shore alinement, to locate new hydrologic structures, to determine bank heights and dry gap widths, and to obtain other information.

Literature sources, depending on quality and format, may be primary sources of information, or they may be used to fill information gaps that cannot be filled through the analysis of maps or aerial photography. Literature sources include water resources data collected by government agencies, information obtained from hydrology texts, and water resource intelligence studies.

2.2 Drainage Basins

Most of the information required to complete the drainage basin overlay and data tables can be derived from topographic maps of 1:50,000, or larger, scale. When a topographic map of the area of interest is not available, or is very old, a mosaic of vertical aerial photographs can be used to provide the base map from which to add information. Additional source materials include the watercourses and water bodies factor overlay and drainage basin management studies.

2.3 Ground Water

Source materials that should be incorporated into the ground water analysis include large-scale topographic maps which should be at 1:50,000, or larger, scale. These maps are used as a base for presenting ground water data collected from other sources. If a suitable topographic map is unavailable, a planimetric map or vertical aerial photo mosaic may be used.

Additional sources include all available data on the hydrology and geology of the area of interest. This includes published information from technical publications and articles and unpublished data available from government agencies and bilateral aid investigations. Private sources such as oil companies, mining companies, and consulting firms should be contacted for additional geologic and hydrologic information.

3. PROCEDURAL OUTLINE

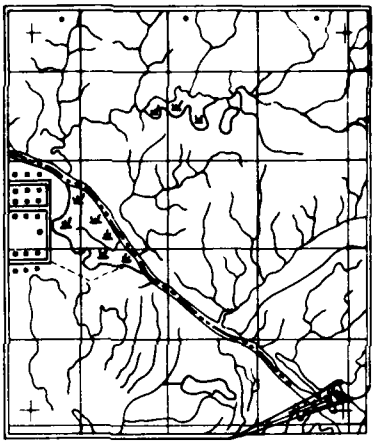
This section provides an overview of the step-by-step procedures required to perform a complete drainage and water resources analysis; the final product of this analysis being three factor overlays, one each for watercourses and water bodies, drainage basins, and ground water. The outline is presented as a pictorial flow diagram showing what analyses are required and the sequence in which they are normally performed.

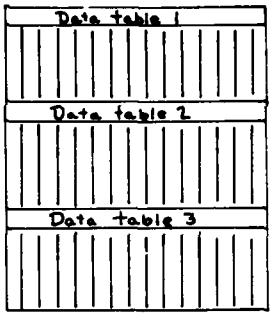
What is to be done is indicated in this section and how it is done is explained in the Analysis and Interpretation Procedures section. Although the flow diagram illustrates many separate steps for clarity, it will often be more practical to combine two or more steps into a single operation.

3.1 WATERCOURSES AND WATER BODIES

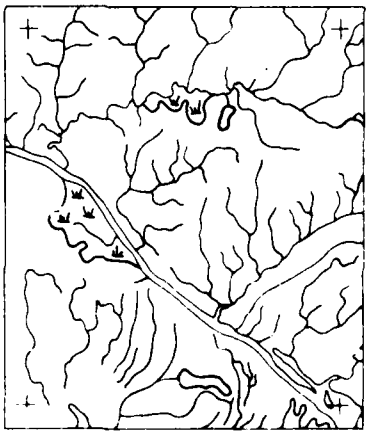
3.1.1 TOPOGRAPHIC MAP ANALYSIS

a. Register overlay material to the 1:50,000 topographic map.



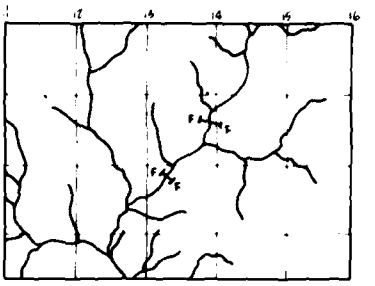


b. Prepare data table worksheets.

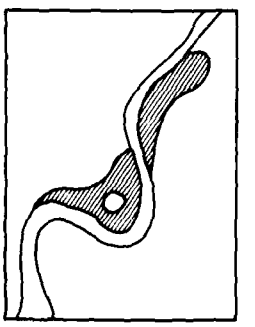


c. Trace the alinement of all watercourses, water body shorelines and boundaries of wet areas.

d. Record the location of all existing fords and ferries.



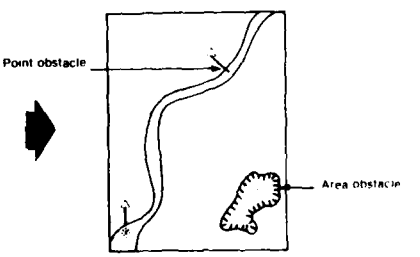
e. Trace the boundaries of all areas subject to flooding.



f. Identify all point and area obstacles which pose obstacles to movement. Review the Coastal Hydrography Section of AMS TM S-1 and Appendix A-2 of this guide for appropriate symbology.

COASTAL HYDROGRAPHY

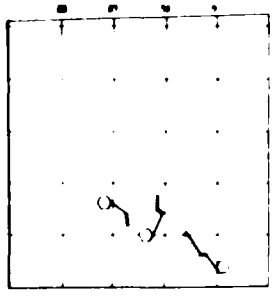
FEATURE	LARGE SCALE	MEDIUM SCALE	SMALL SCALE	
WRECKS				



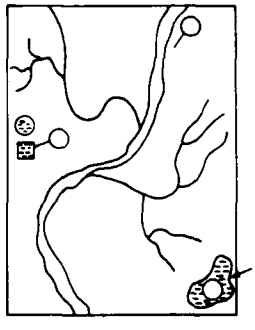
g. Record the location of hydrologic structures on the overlay. Symbolize each structure as shown in Table 2 - Overlay Representations of Miscellaneous Features.

TABLE 2. (CONTINUED). OVERLAY REPRESENTATIONS OF MISCELLANEOUS FEATURES

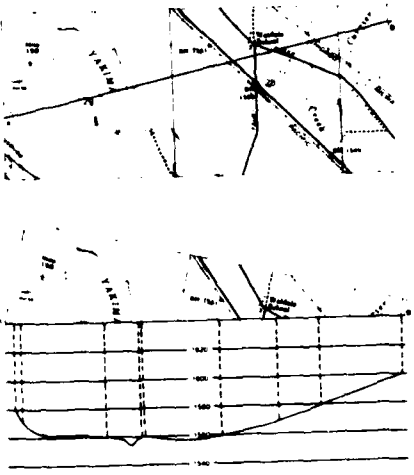
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS



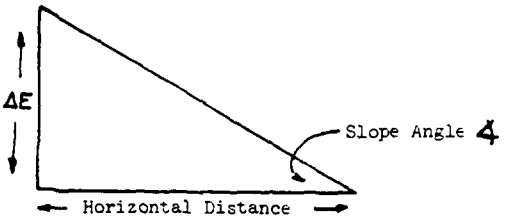
h. Record the location of special features/ areas on the overlay. These are important hydrologic features that do not fall into one of the other factor overlay categories.



i. Construct cross section sketches at selected locations along the watercourse. Record these sketches at an appropriate scale in Data Table 1. (This information should be obtained after watercourse segments have been established. See section 4.2.2.6.)

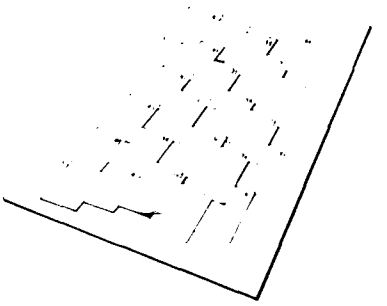


j. Use watercourse segment horizontal distance and change in elevation between upstream and downstream limits (ΔE) to calculate slope angle for each watercourse segment. Record slope angle in Data Table 2. (This information should be obtained after watercourse segments have been established. See section 4.2.2.6.)

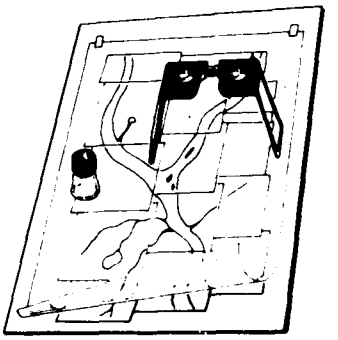


3.1.2 PHOTO ANALYSIS

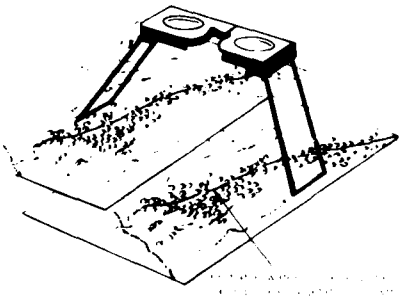
a Prepare Mosaic from alternate photos



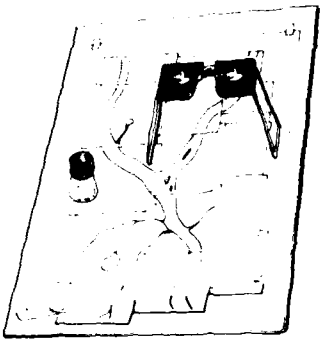
b Place overlay material over the mosaic

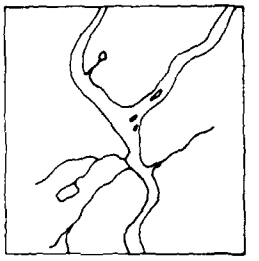


c Examine the photos stereoscopically and determine if the alinement of all watercourses, especially small obscure ones, have been included on the map-derived (working) overlay.



d. Transfer the photo-derived alinement information to the map-derived (working) overlay.

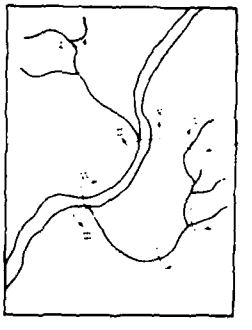




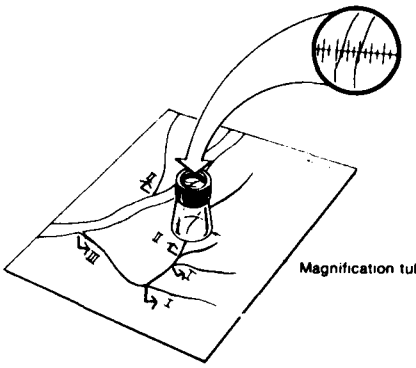
e Stereoscopically measure each watercourse's dry gap and determine where watercourse width class transitions occur

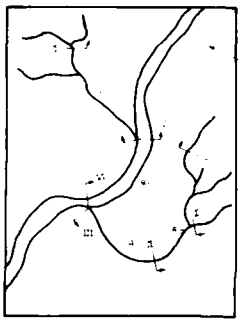
f Mark each width class transition point by drawing a line perpendicular to the watercourse and adding an arrow pointing upstream

Width Class	Interval (m)
I	0-3
II	3-10
III	10-18
IV	18-25
V	25-35
VI	35-50
VII	>50



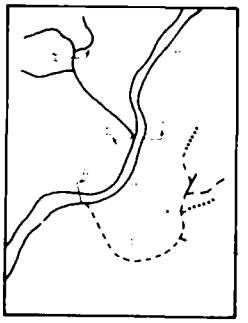
g. Determine the average dry gap distance for each watercourse segment. Record this value on the overlay.



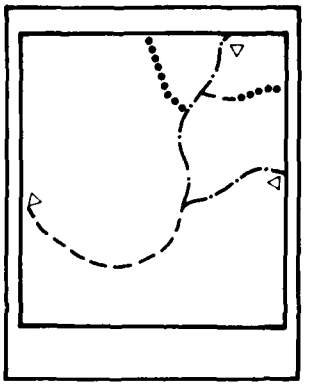


h. Erase original alinement symbology and replace with the watercourse symbol that represents the measured gap width.

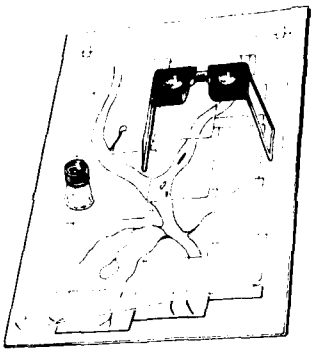
Width Class	Gap Width (m)	Symbol
I	< 3	
II	3-10	
III	10-18	
IV	18-25	
V	25-35	
VI	35-50	
VII	>50	Drawn to Scale

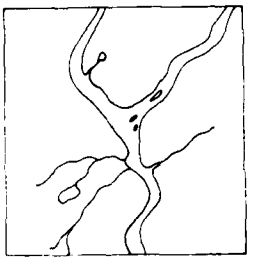


i. As required, assign the terminal point symbol to watercourses 3m or greater in width



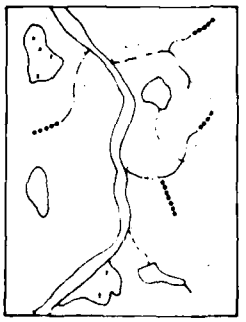
j. Compare the working overlay with the photos to determine if all watercourses, water bodies and wet areas present on the photos have been recorded on the overlay





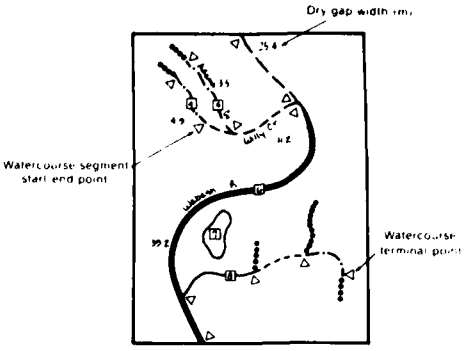
Working Overlay

k. Assign an ID number to each watercourse, water body, and wet area. Classify each into a hydrologic class and record this information in the data table

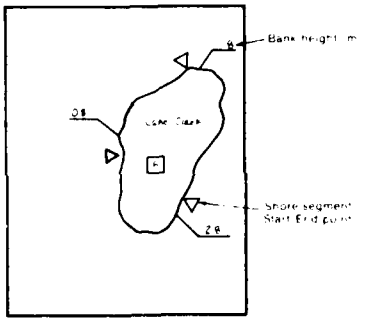


[illegible]	[illegible]	[illegible]	[illegible]
1	None	Swamp	
2	Mud River	River	
3	Wells Creek	Stream	
4	Lake Smith	Lake	

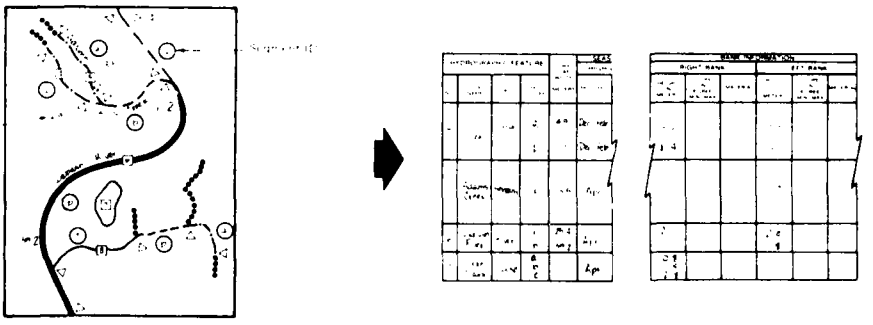
l. Establish watercourse segment start/end points. Segments on watercourses with gap widths 50m or less are established on the basis of width class. Segments on watercourses with gap widths greater than 50m are selected on the basis of bank heights.



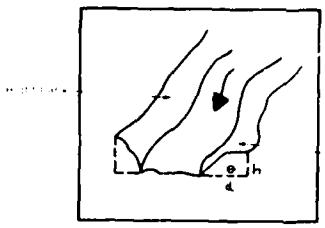
m. Establish water body shore segment start/end points. Segments are selected on the basis of bank heights.

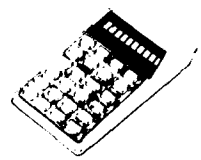


n. Assign identification letters to all watercourse and water body segments. Record these letters in the data tables.



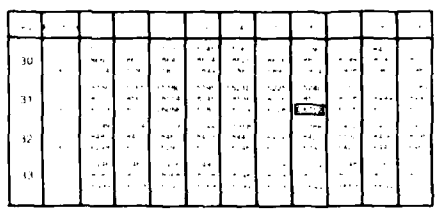
o. Determine the minimum and maximum bank slopes for each watercourse and water body segment. Record these values on the overlay and in Data Table 1.

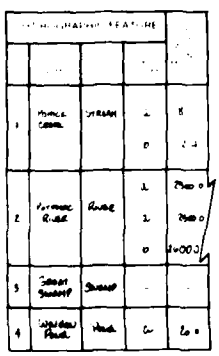


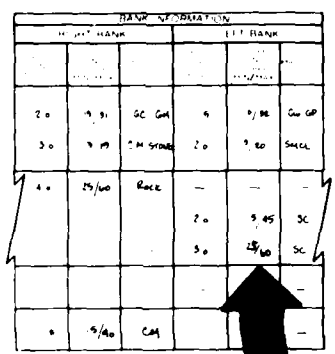


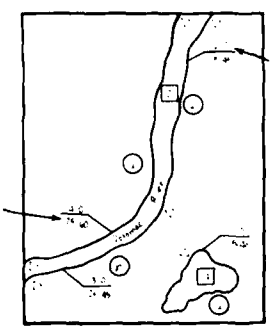
$$\text{TANGENT } \theta = \frac{h}{d}$$

Natural Sines, Cosines and Tangents









p. Compare the working overlay with the photos to determine if all flooded areas shown on the photos are outlined on the overlay. Assign an ID number to each flooded area. Record these numbers in Data Table 3.

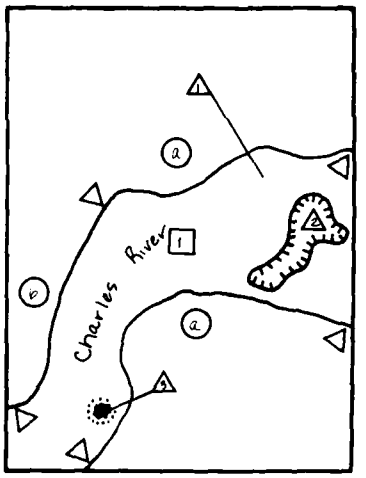
HYDROGRAPHIC FEATURE

ID NO	LOCAL NAME	CLASS
1	Police Creek	Stream
2	Potomac River	River

AREAS SUBJECT TO FLOODING

ID NO	START DATE	MEAN DEPTH (m)	DURATION (DAYS)	AREA
1	4/72	2.0	3	Heavy Rain
2	4/72	3.0	4	Ice Jam

q. Compare the working overlay with the photos to determine if all point and area obstacles shown on the photos have been included on the overlay. Assign an ID number to each point and area obstacle. Record these numbers in Data Table 2.



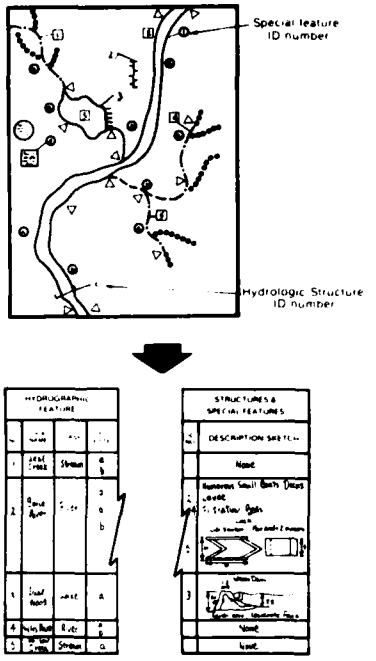
HYDROGRAPHIC FEATURE

ID NO	LOCAL NAME	CLASS	SEG NO
1	Charles River	River	a b a

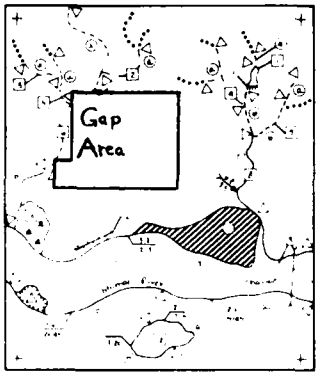
OBSTACLES

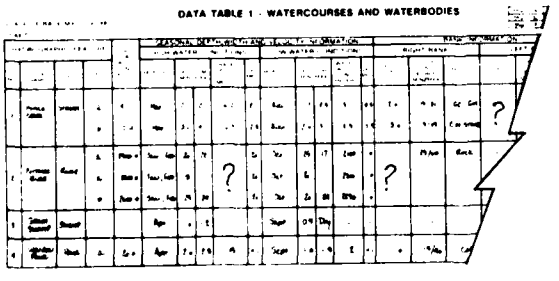
ID NO	DESCRIPTION SKETCH
1	Uprooted Fall Trees
2	Shoal Area
3	Rocks Awash

r. Compare the working overlay with the photos to determine if all hydrologic structures and special features/areas shown on the photos have been included on the overlay. Assign an ID number to each hydrologic structure and special feature/area. Record these numbers in Data Table 3.



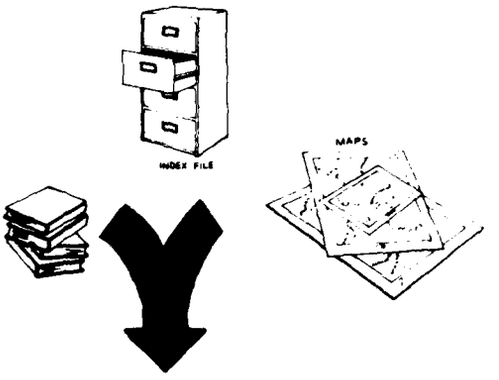
s. Study the working overlay and data tables and note those areas for which information is lacking or incomplete. Attempt to fill information gaps through literature analysis.





3.1.3 LITERATURE ANALYSIS

a. Assemble drainage and water resource information for the country or area of interest. Contact literature and map sources as necessary to obtain specific information.



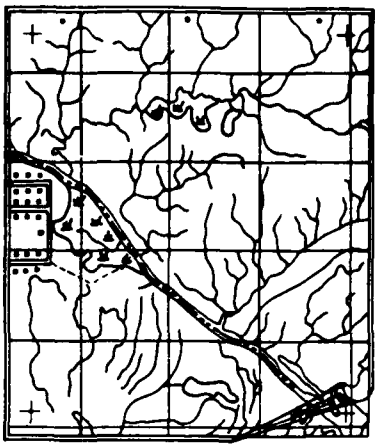
b. Analyze the information and extract data as *required for completion of the* overlay and data tables.

DATA TABLE 1 - WATERCOURSES AND WATERBODIES

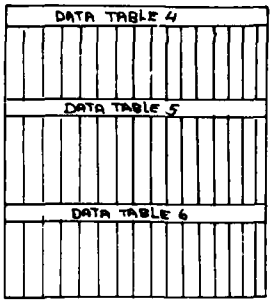
3.2 DRAINAGE BASINS

3.2.1 TOPOGRAPHIC MAP ANALYSIS

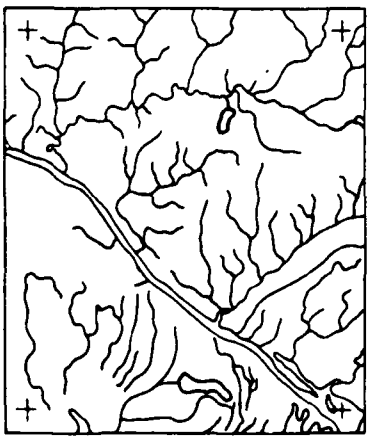
a. Register overlay material to the 1:50,000 topographic map or to the watercourses and water bodies factor overlay, if completed.



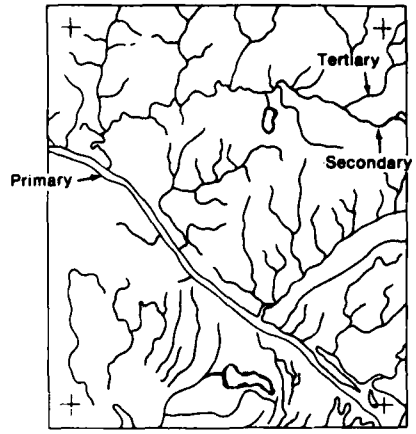
b Prepare data table worksheets.



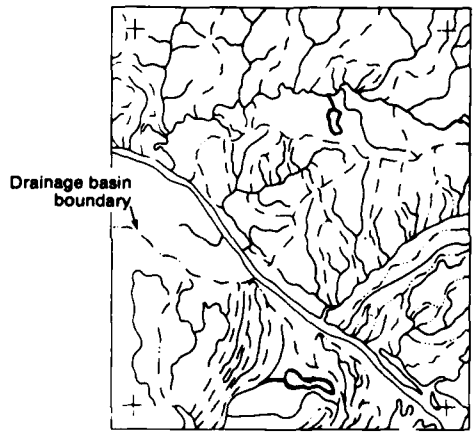
c. Trace the alinement of all watercourses and water body shorelines.



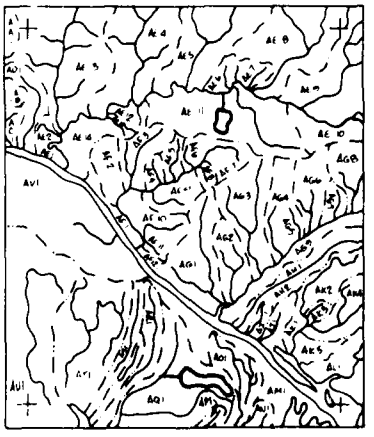
d. Determine watercourse hierarchy based upon the relative size of watercourses within the 1:50,000 factor overlay. (Consult adjacent topographic maps for additional information.)



e. Determine the boundaries of each primary, secondary, and tertiary drainage basin based on the lay of the land.



f. Assign identification nomenclature to each outlined drainage basin. Record the basin identifiers in column 1 of the appropriate data table.



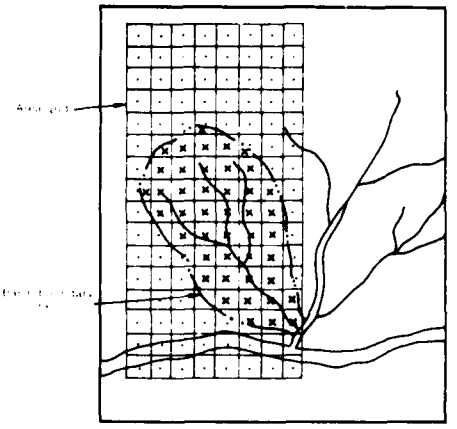
DATA TABLE 6. TERTIARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrology Type	Structures UTM Coord
AA 1	Smith Creek	12.2	1.1	None	
AA 2	Salmon Creek	7.5	0.4	None	
AA 3	Shell Creek	17.5	1.6	Sec. Table 4	
AA 4	Red Creek	5.2	0.3	None	
AA 5	Mill Creek	15.1	2.1	None	

g Determine the area of each outlined basin. Record this value in the appropriate data table.

DATA TABLE 6 TERTIARY DRAIN

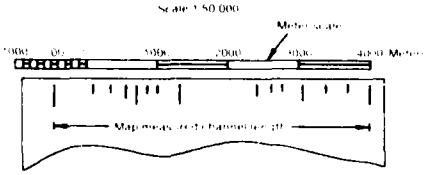
1	2	3	4
ID	Name	Basin Area (Hectares)	Channel Length (km)
BC 5	Smith Creek	12.2	
BC 6	Salmon Creek	7.3	
BC 7	Shell Creek	17.5	

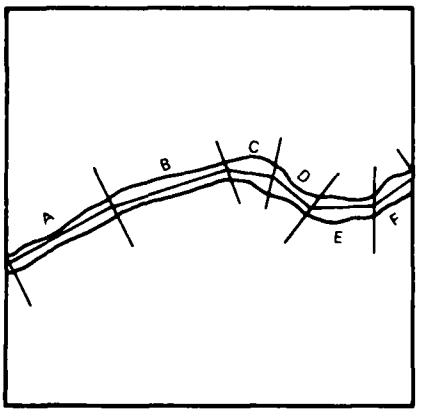


h Measure the length of the main watercourse in each outlined basin. Determine true watercourse length by comparing the map-measured length with the meter scale at the bottom of the map. Record this value in the appropriate data table.

DATA TABLE 5 SECONDARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures Type	UTM Coord
[illegible]	[illegible] Creek	[illegible]	[illegible]	None	
[illegible]	[illegible] Creek	37.4	3.1	See Table 6	





i Determine the type and UTM coordinates of hydrologic structures located in each drainage basin. Symbolize the structures on the overlay. Record type and UTM information in the appropriate data table.

DATA TABLE 4 PRIMARY DRAINAGE BASINS

1	2	3	4	5	6	7	8	9
ID	Name	[illegible]	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures Type	UTM Coord	No. of Secondary Drainage Basins	No. of Tertiary Drainage Basins
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

3. Clean up the final data tables and overlay. Add marginal information to the overlay as outlined in Appendix A-3 of this guide.

DATA TABLE 4 PRIMARY DRAINAGE BASINS

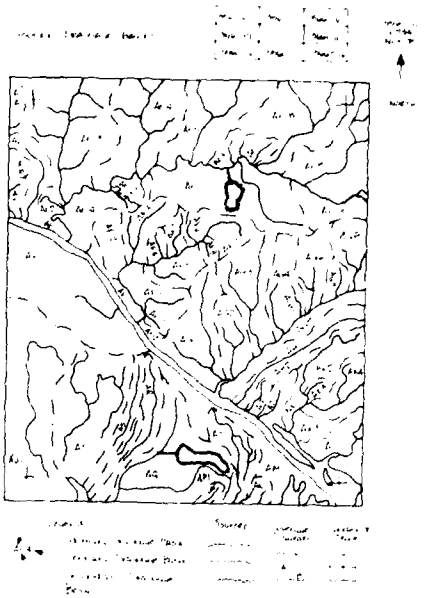
1	2	3	4	5	6	7	8	9
ID	Name	[illegible]	Basin Area Hectares	[illegible]	Hydrology Type	Hydrology [illegible]	No. of Secondary Drainage Basins	No. of Tertiary Drainage Basins
A	Susquehanna River	Muore Co	76.3	6.2	Concrete Dam	[illegible]	2	5

DATA TABLE 5 SECONDARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area Hectares	[illegible]	Hydrology Type	Hydrology [illegible]
AA	[illegible] Creek	7.1	2.1	None	
AB	[illegible] Creek	37.4	5.1	Sea Table 4	

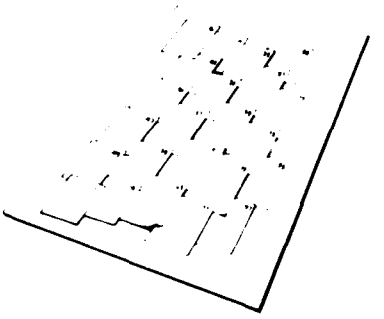
DATA TABLE 6 TERTIARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area Hectares	[illegible] Length (km)	Hydrology Type	Hydrology [illegible]
AA 1	Green Creek	2.2	2.1	None	
AA 2	Salmon Creek	7.3	0.4	None	
AB 1	Small Creek	7.5	1.6	Sea Table 4	
AB 2	Red Creek	5.2	0.3	None	
AB 3	Mill Creek	5.1	2.1	None	

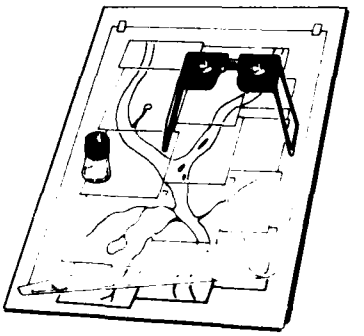


3.2.2 PHOTO ANALYSIS (PHOTO ANALYSIS IS PROBABLY NOT NECESSARY IF THE TOPOGRAPHIC MAP ANALYSIS WAS COMPLETED SATISFACTORILY)

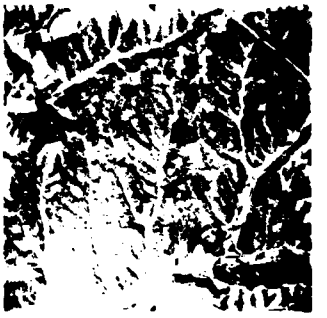
a Prepare mosaic from alternate photos



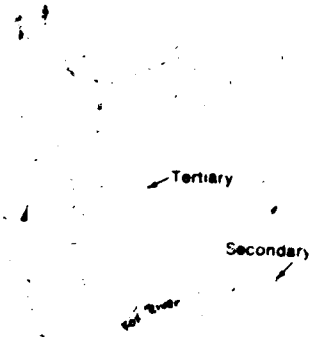
b Place overlay material over the mosaic



c Examine the photos stereoscopically and trace the alignment of all visible drainage channels



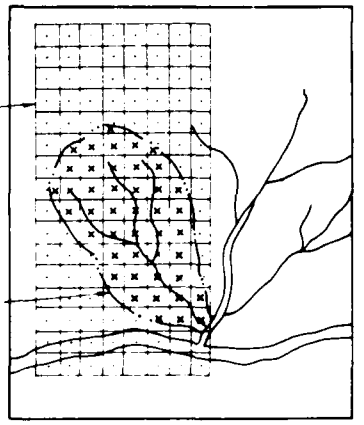
AIR 1P-51



DATA TABLE - SECONDARY DRAIN

1	2	3	4	
ID	Name	Basin Area (sq. miles)	Channel Length (km)	
BC	Fox River			

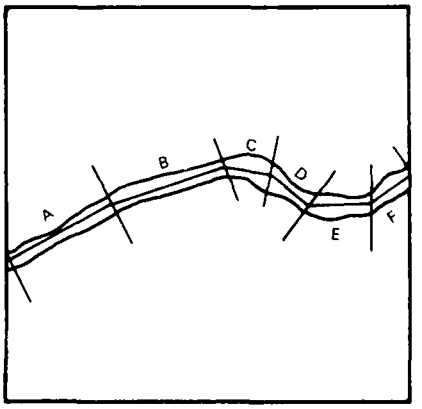
g Determine the area of each outlined basin. Record this value in the appropriate data table.



DATA TABLE 6 TERTIARY DRAIN

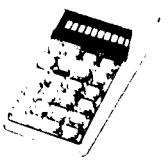
1	2	3	4
ID	Name	Basin Area (Hectares)	Channel Length (km)
BC 5	Smith Creek	12.2	
BC 6	Salmon Creek	7.3	
BC 7	Shell Creek	17.5	

h Measure the length of the main watercourse in each outlined basin. Record this value in the appropriate data table.



DATA TABLE 6 TERTIARY DRAINAGE BA

1	2	3	4	5
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrolog Type
BC 5	Smith Creek	12.2	1.1	Non
BC 6	Salmon Creek	7.3	0.4	Non
BC 7	Shell Creek	17.5	1.6	Sc



1. *Determine the type and UTM* coordinates of hydrologic structures located in each drainage basin. Symbolize the structures on the overlay. Record type and UTM information in the appropriate data table.

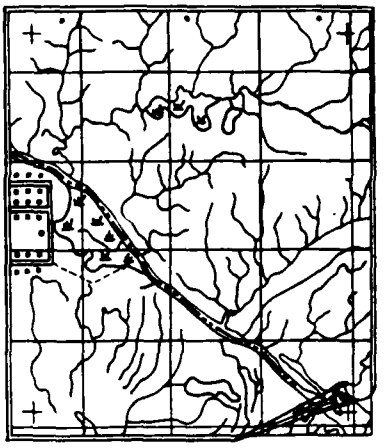
DATA TABLE 4 - PRIMARY DRAINAGE BASINS

1	2	3	4	5	6	7	8	9
ID	Name	Political Unit(s)	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures		No of Secondary Drainage Basins	No of Tertiary Drainage Basins
					Type	UTM Coord		
A	Susquehanna River	Moore Co.	56 3	6.2	Concrete Dam	9226307	2	5

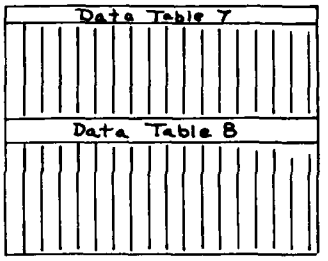
3.3 GROUND WATER

3.3.1 TOPOGRAPHIC MAP ANALYSIS

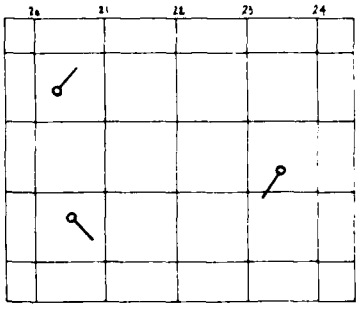
a Register overlay material to the 1:50,000 topographic map.



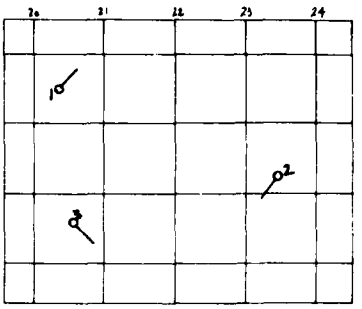
b Prepare data table worksheets



c Record the location of all wells and springs on the overlay.



d. Assign an ID number to each well and spring symbolized on the overlay. Record the ID number, type of feature, and name, if known, in columns 1, 2, and 3 respectively of Data Table 7.



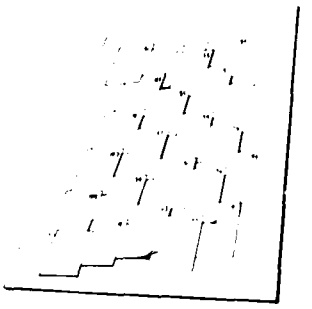
1	2	3	4	5	6
ID No	Type	Name	UTM Coordinates	Yield (gpm)	Da Mea
1	Spring	Unnamed			
2	Well	Unnamed			
3	Well	Unnamed			

e. Determine the UTM coordinates of each spring and well symbolized on the overlay. Record the coordinates in column 4 of Data Table 7.

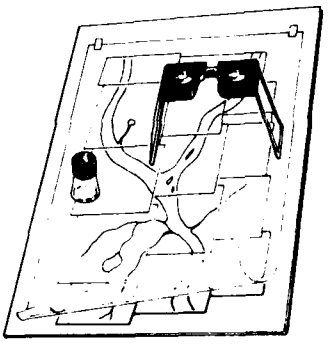
1	2	3	4	5	6
ID No	Type	Name	UTM Coordinates	Yield (gpm)	Da Mea
1	Spring	Unnamed	3650427		
2	Well	Unnamed	3650493		
3	Well	Unnamed	3651482		

3.3.2 PHOTO ANALYSIS

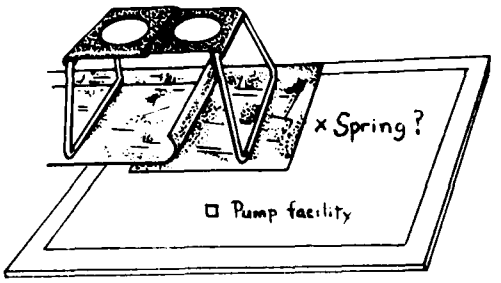
a. Prepare Mosaic from alternate photos



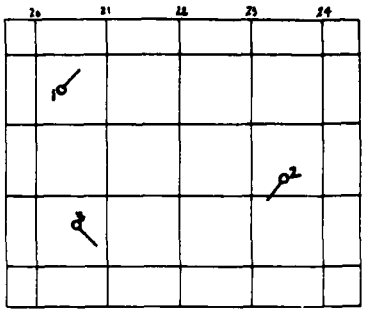
b. Place overlay material over the Mosaic



c. Examine the photos stereoscopically and determine the location of manmade features associated with ground water such as canals and pump facilities. Note the location of these features on the overlay.



d. Assign an ID number to each well and spring symbolized on the overlay. Record the ID number, type of feature, and name, if known, in columns 1, 2, and 3 respectively of Data Table 7.

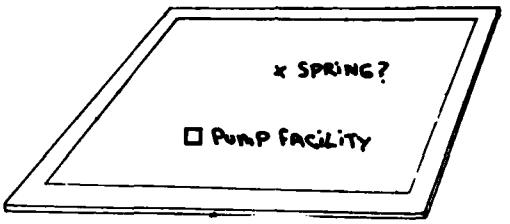


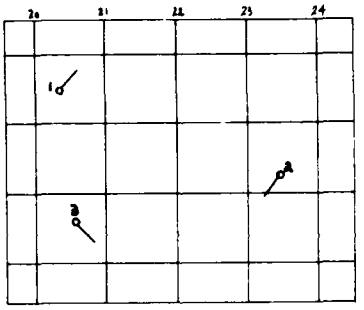
1	2	3	4	5	6
ID No.	Type	Name	UTM Coordinates	Yield (gpm)	De Mea
1	Spring	Unnamed			
2	Well	Unnamed			
3	Well	Unnamed			

e. Determine the UTM coordinates of each spring and well symbolized on the overlay. Record the coordinates in column 4 of Data Table 7.

1	2	3	4	5	6
ID No.	Type	Name	UTM Coordinates	Yield (gpm)	De Mea
1	Spring	Unnamed	3450427		
2	Well	Unnamed	3460934		
3	Well	Unnamed	3451427		

f. Transfer the photo-derived information to the map-derived overlay. Attempt to obtain quantitative information from other data sources to support and confirm photo interpretation.

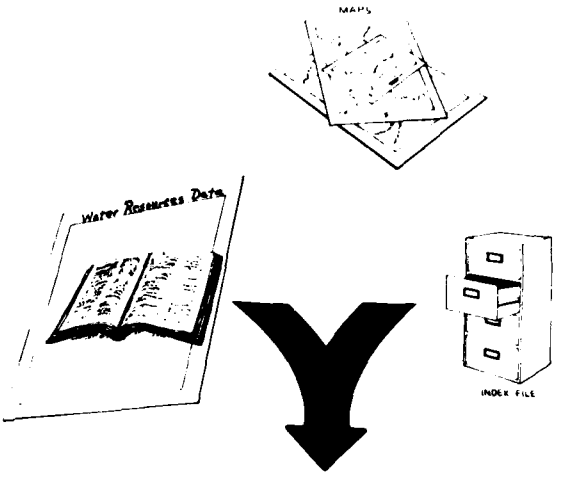




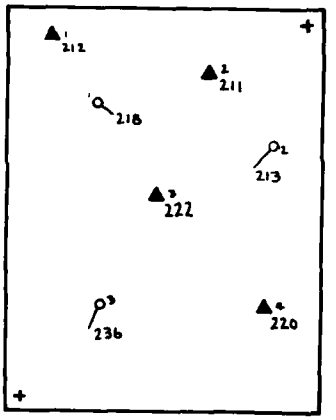
Map-Derived Overlay

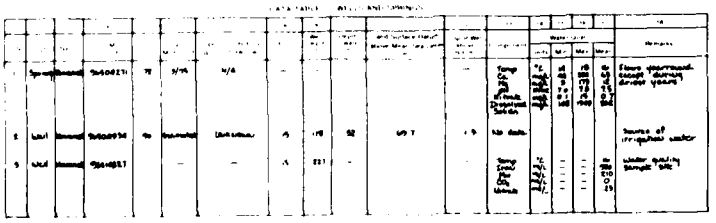
3.3.3 LITERATURE ANALYSIS

a Make a thorough literature search for geologic and hydrologic documents concerning the area of interest These include geologic maps, hydrogeological surveys, well logs, and water quality data

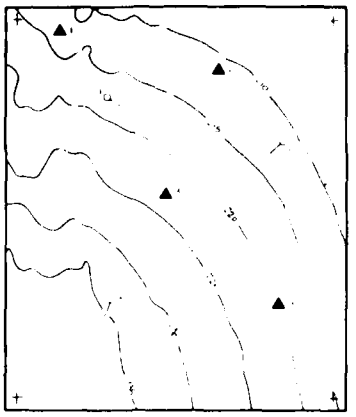


b Analyze this information Record depth to water table information on the overlay Extract other data as required for completion of the data tables

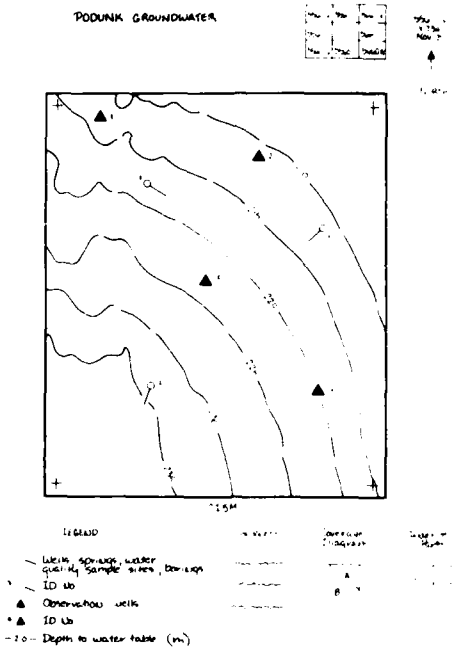




c. Use the ground water elevation information compiled in previous steps to construct ground water elevation contour lines. These are drawn by interpolation between known ground water levels.



d. Clean up the final overlay and add marginal information as outlined in Appendix A-4 of this guide.



4. ANALYSIS AND INTERPRETATION PROCEDURES

4.1 Introduction

This section, along with Supplementary Procedures (section 4.5), provides detailed instructions for extracting, reducing, and recording information required for each of the drainage and water resources data fields, i.e. watercourses and water bodies, drainage basins, and ground water. Three principal sources of information: topographic maps, aerial photography, and scientific literature, are treated in this guide.

Each data field is organized into three sections corresponding to type of source material. Although organized in this manner for ease of presentation, the terrain analyst will seldom separate the analysis in this manner. In most cases, the analysis of each type of source material will not occur independently, but rather the data acquired from one source will be used to support the interpretation of another source. In this way, information from all sources can be combined to produce a comprehensive, integrated drainage and water resources analysis.

4.2 Watercourses and Water Bodies

The following paragraphs provide the steps necessary to complete the requirements for preparing the watercourses and water bodies overlay and supporting data tables using: 4.2.1 Topographic Map Analysis, 4.2.2 Photo Analysis, and 4.2.3 Literature Analysis. The procedures referred to under Topographic Map, Photo, and Literature Analyses are in section 4.5, "Supplementary Procedures".

4.2.1 Topographic Map Analysis

4.2.1.1 Alinement of Watercourses and Water Body Shorelines

Step 1. Use Procedure 1 (4.5.1) to register the overlay material to the 1:50,000 scale topographic map or drainage compilation.*

Step 2. Use Procedure 2 (4.5.2) to prepare the data tables.

Step 3. Read through each of the following steps before starting the analysis to become familiar with the overall approach taken to the problem of recording watercourse and water body shoreline alinement.

Step 4. Use a prisma color or equivalent pencil to trace the alinement of all watercourses and water body shorelines. Begin by tracing the watercourses in the drainage basin nearest the upper left corner of the map sheet. Complete tracing the watercourses and water body shorelines in that basin, then move to the next basin to the right. Progress across and down the map sheet until all water courses and water body shorelines have been traced on the overlay.

*The drainage reproducible is a photo negative from which the topographic map is compiled. A positive drainage compilation of this reproducible can be easily made on frosted mylar by a rub-on process. If available, the drainage compilation can be used in place of the 1:50,000 topographic map for determination of the alinement of watercourses and water body shorelines.

Step 5. Trace the alinement of all watercourses (perennial) and all water body shorelines (perennial, intermittent, or dry) with a solid black line. Intermittent or dry watercourse alinements are symbolized with a dashed line. The solid and dashed lines are used only to indicate alinement and will be altered later in the analysis when gap widths are determined.

Step 6. Occasionally check the alinement at the ticks at each corner of the overlay to ensure it is properly registered to the topographic map.

Step 7. Remember that watercourses symbolized by two lines on the 1:50,000 scale topographic map are 25 m or greater in width and are the only ones drawn to scale. Make sure the gap widths of all double line streams are traced exactly on the overlay.

Step 8. When the alinements of all watercourses and water body shorelines have been traced on the overlay, check to see that no small water bodies or small watercourse tributaries have been overlooked. In particular, study the contour lines near the furthest upstream portions of each watercourse. Where appropriate, estimate the approximate alinement of watercourses not included on the map by connecting identations in adjacent contour lines (see figure 4.1). This step cannot be performed from information on the drainage compilation.

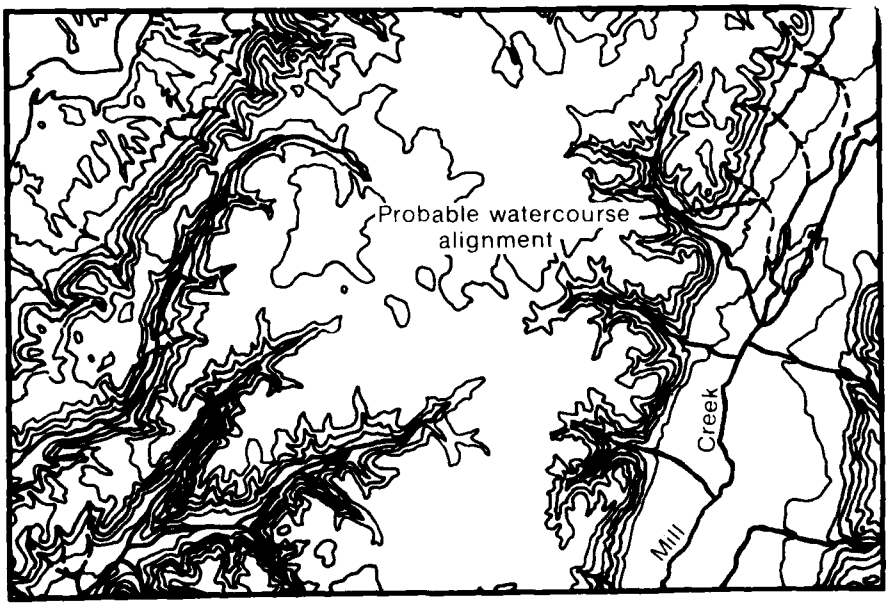


Figure 4.1 Watercourse Alinement Based on Contours.

Step 9. Place the water body and watercourse names on the overlay in approximately the same size lettering as used on the base map (see figure 4.2). Do not use names on the overlay where they would clutter the overlay or obscure other data.

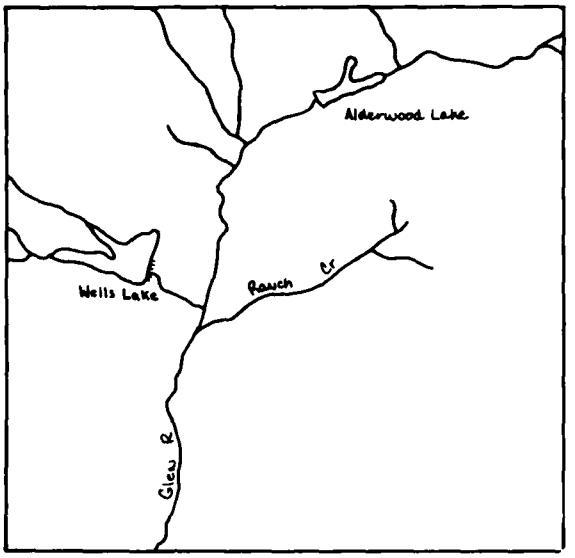


Figure 4.2 . Placement of Watercourse and Water Body Names.

4.2.1.2 Wet Area Boundaries

Step 1. Trace the boundaries of wet areas on the overlay. These areas include marshes, swamps, paddy/wet crops, peat bogs, etc. and are identified by the overlay symbol for wet areas (figure 4.3).

Step 2. If any doubt exists about which features are considered wet areas, consult Table 1. Overlay Representations of U.S. Inland Hydrography Symbols.

Step 3. Hand draft the wet area symbols in accordance with appendix A2.

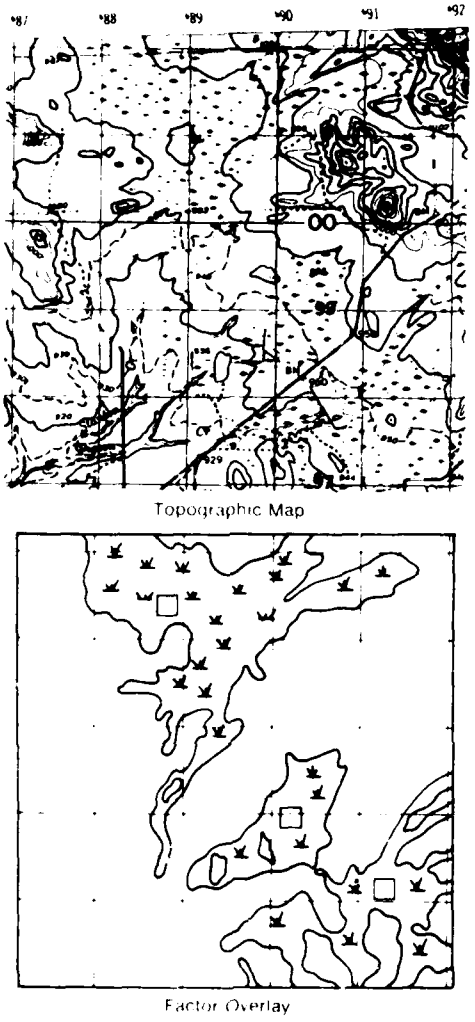


Figure 4.3 Topographic Map and Factor Overlay of Same Area with Wet Areas Bound.

4.2.1.3 Fords and Ferries

Step 1. Starting in the upper left corner of the overlay and working across and down, systematically record the locations of known crossing sites, i.e. fords and ferries (figure 4.4). Detailed characteristics of fords and ferries cannot be derived from the topographic map. To determine whether a given ford or ferry is suitable as an infantry or vehicular crossing site, one must analyze additional sources, including aerial photography and information on vehicle stream crossing capabilities.

TABLE 1. OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

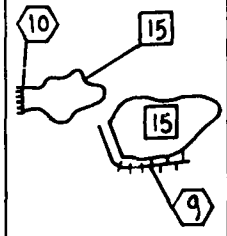
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Reservoir (natural shorelines)	An artificial lake formed by the water impounded by a dam		Trace the shore alignment of the resevoir on the overlay Identify dams and levees, where present, with the appropriate symbolization As-sign an ID number to each feature and describe each in Data Tables 1-3
	Perennial double line stream	Contains water for an average of 6 or more months annually Double line perennial streams measure 0 02 inch *(0 5mm) or more in width at normal* stage	See remarks	Trace the alignment of these features on the overlay Measure stream width and record this value in Data Table 1 Use the watercourse symbol which corresponds to the measured gap width
	Perennial single line stream	Contains water for an average of 6 or more months annually Single line perennial streams measure less than 0 02 inch (0 5mm) in width	See remarks	Trace the alignment of these features on the overlay Measure stream width on aerial photography using Pro-cedure 6 and record width in Data Table 1 Use the water course symbol which corresponds to the measured gap width

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Braided stream	Watercourse which subdivides into an interlaced pattern of channels through the riverbed.	See remarks	Trace the alignment of braided streams on the overlay. When symbolized with a double line, stream width may be measured on the map. Confirm map measurements with aerial photography. When single line, measure stream width on aerial photography using Procedure 6. Use the watercourse symbols which correspond to the measured gap widths.
	Meandering stream	A stream which follows a winding course through level land.	See remarks	Trace the alignment of meandering streams on the overlay. Measure stream width and record this value in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.
	Single line intermittent or dry stream (wadi or wash)	Contains water for an average of less than 6 months annually. Single line intermittent or dry streams measure less than 0.04 inch (1mm) in width.	See remarks	Trace the alignment of these features on the aerial photography and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMAPKS
	Double line intermittent or dry stream (wash or arroy	Contains water for an average of less than 6 months annually. Channel is shown as perennial or intermittent. Double line intermittent or dry streams measure 0.04 inch (1mm) or more in width.	See remarks	Trace the alignment of these features on the overlay. Measure stream width using Procedure 6 and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.
	Unsurveyed, double line	A watercourse whose alignment cannot be definitely determined	See remarks	Trace the alignment of these features on the overlay. Confirm the alignment with aerial photography when possible. Measure stream width on the photography and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.
	Unsurveyed, single line	A watercourse whose alignment cannot be definitely determined	See remarks	Same remarks as above.

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

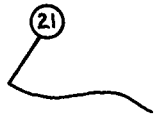
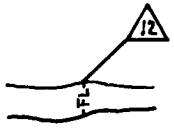
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Dissipating stream	A watercourse which dissipates by seeping into the ground. Separate branches are shown to scale when possible.	See remarks	Trace the alignment of dissipating streams on the overlay. When symbolized with a double line, measure stream width on the map. Confirm map measurements with aerial photophotography. When single line, measure stream width on aerial photography using Procedure 6. Use the watercourse symbol which corresponds to the measured gap width.
	Disappearing stream	A watercourse which flows into a sinkhole and continues its course in a subterranean channel.		Trace the alignment of disappearing streams on the overlay. Measure stream width on aerial photography using Procedure 6. Use the watercourse symbol which corresponds to the measured gap width. Identify the sinkhole with a special feature symbol, assign it an ID number and describe/sketch it in Data Table 3.
	Large falls	Created by a vertical or near vertical descent of a stream; sometimes called a cataract or cascade. Falls are symbolized as large when the stream is wider than 0.10 inch.		Identify the falls with an obstacle symbol, assign it an ID number and describe/sketch it in Data Table 2.

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

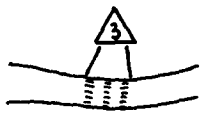
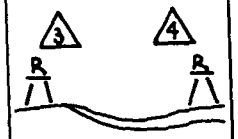
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Small falls	Created by vertical or near vertical descent of a stream; sometimes called a cataract or cascade. Falls are symbolized as small when the stream is less than 0.10 inch wide		Same remarks as large falls
	Large rapids	Formed where the river current moves with great swiftness, the surface being broken by obstructions such as rocks and boulders. Rapids are symbolized as large when the stream is wider than 0.10 inch.		Identify the rapids with an obstacle symbol, assign it an ID number and describe/sketch it in Data Table 2
	Small rapids	Rapids are symbolized as small when the stream is less than 0.10 inch wide		Same remarks as large rapids.
	Navigable double line canal or canalized stream	A maintained waterway used by commercial craft. Double line canals measure 0.02 inch (0.5mm) or more in width	See remarks	Measure canal width and record this value in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Navigable single line canal or canalized stream	A maintained waterway used by commercial craft. Single line canals measure less than 0.02 inch (0.5mm) in width	See remarks.	Measure canal width on aerial photography using Procedure 6 and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width
	Abandoned double line canal (containing water)	A canal which is not in use and is not maintained, could be made operational with a minimum of repairs	See remarks.	Same remarks as navigable double line canal
	Abandoned single line canal (containing water)	Same as above	See remarks	Same remarks as navigable single line canal
	Abandoned double line dry canal	A canal which is dry or contains insufficient water for operation, there is no evidence of plans to make it operable	See remarks	Same remarks as navigable double line canal.
	Abandoned single line dry canal	Same as above.	See remarks	Same remarks as navigable single line canal

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

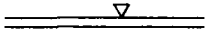
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Double line canal under construction	New or existing canal undergoing construction; there is no evidence that the work will be completed by the time the map is published. If alignment is not definite, the label "Approximate alignment" is added.	See remarks.	Trace the alignment of canals under construction on the overlay. Assuming the available aerial photography was acquired at a more recent date than the map publication date, use the photography to determine if the canal is currently under construction. Note your findings in the data tables. Measure canal width on the photography using Procedure 6 and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.
	Single line canal, under construction	Same as above.	See remarks.	Same remarks as double line canal under construction.
	Limiting tick	Used to indicate the degree of operability of a canal.		Use the symbol which marks watercourse segment start and end points.

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Perennial double line ditch	A man-made excavation used for the control and movement of water; it contains water for an average of 6 or more months annually. Double line ditches measure 0.02 inch (0.5mm) or more in width	See remarks	Measure ditch width using Procedure 6 and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.
	Perennial single line ditch (major and minor)	Ditches are used to drain swamps and areas subject to natural inundation. Major ditches are supply ditches. minor ditches connect supply ditches and form the basic network of the drainage or irrigation system. Single line ditches measure less than 0.02 inch (0.5mm) in width.	See remarks	Measure ditch width on aerial photography using Procedure 6 and record width in Data Table 1. Use the watercourse symbol which corresponds to the measured gap width.
	Intermittent ditch	Contains water for an average of less than 6 months annually. Regardless of width, all intermittent ditches are symbolized alike.	See remarks	Same remarks as perennial single line ditch

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

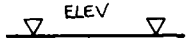
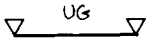
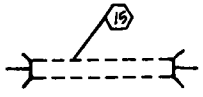
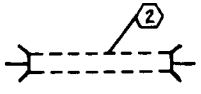
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Aqueduct, penstock, pipeline, or flume (ground level)	See Glossary for definition of features.		Use the watercourse segment symbol to delimit boundaries of the feature. Measure the width of the feature on aerial photography using Procedure 6 and record width in Data Table 1. Classify the watercourse segment as an aqueduct, penstock, pipeline or flume in the Data Tables.
	Aqueduct, penstock or flume (elevated)	Same remarks as above.		Same remarks as above.
	Aqueduct, penstock or pipeline (underground)	Same remarks as above.		Same remarks as above.
	Aqueduct in traversable tunnel.	Tunnel permits passage by foot.		Assign an ID number to the feature. This number is used to reference the feature in Data Table 3. Indicate in the description that the tunnel is foot traversable.
	Aqueduct in nontraversable tunnel.	Tunnel does not permit passage by foot.		Assign an ID number to the feature. This number is used to reference the feature in Data Table 3. Indicate in the description that the tunnel is not foot traversable.

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

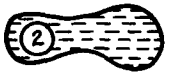
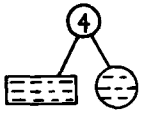
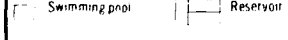
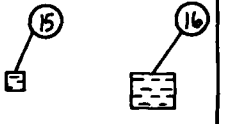
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Karex (kanat, qanat, etc.)	An underground conduit which carries water from its source to points of distribution. Regularly spaced shafts provide entry for construction and maintenance.		Trace the alignment of the Karex on the overlay. Treat it as an underground aqueduct.
	Salt evaporators	Shown by delineating the outline and major separations. When map scale prevents inclusion of all secondary separations, a representative pattern is shown.		Assign an ID number to the feature. Use the symbol for special areas and describe it in Data Table 3.
	Fishponds and hatcheries	Shown when large enough to plot to scale; limits may be exaggerated if features are of landmark significance.		Same remarks as above.
	Sewage disposal and filtration beds	Same remarks as above.		Same remarks as above.
	Swimming pools and man-made reservoirs	Shown when large enough to plot to scale; limits are exaggerated if the features are of landmark significance.		Same remarks as above.

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

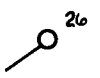
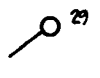
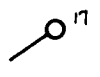
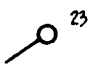
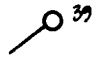
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Well (perennial)	A pit or hole which is sunk, by digging or drilling, below ground level to reach a supply of water. Water is available for an average of 6 or more months annually. Waterholes, walled-in springs, geysers, artesian wells, and fountains are shown as wells and are labeled appropriately.		Assign an ID number to the feature. This number is used to reference the feature in Data Table 7 — Wells and Springs. Indicate in the description the type of well, if shown, and whether it is perennial or intermittent.
	Well (intermittent)	Water is available for an average of less than 6 months annually.		Same remarks as above
	Cistern	A tank or similar artificial enclosure which is used for the collection and storage of water. Underground cisterns are symbolized as wells.		Assign an ID number to the feature. This number is used to reference the feature in Data Table 7 — Wells and Springs.
	Spring (perennial)	A natural outflow of water from a subsurface level. Outflow of water occurs for an average of 6 or more months annually.		Same remarks as above. Also, indicate in the description whether the spring is perennial or intermittent.
	Spring (intermittent)	Outflow of water occurs for an average of less than 6 months annually.		Same remarks as above

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Flow arrow	Shown when the direction of water flow of perennial (double and single line) features is not apparent from the relief portrayal	See Remarks	This information is not normally included on the overlay.
	Water surface elevation	Elevations correspond to the normal water stage.	See Remarks	This information is not normally included on the overlay.
	Marsh in tidal waters	Saturated land that covers and uncovers with the tide and supports reed or grasslike aquatic growth		Trace the boundaries of the marsh on the overlay. Identify the outlined area with the symbol for wet areas. Assign an ID number to the feature and describe it in the Watercourses and Waterbodies Data Tables
	Marsh in nontidal waters	Saturated land, usually covered with standing water that supports reed or grasslike aquatic growth. Shown in the open water area, with its landside limits delineated as the shoreline.		Same remarks as above

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

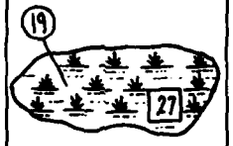
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Swamp	Land which is saturated, though not usually covered, with water. Vegetation occurring in a swamp is shown with its prescribed symbol over printing the swamp symbol.		Trace the boundaries of the swamp on the overlay. Identify the outlined are with the symbol for wet areas. Assign an ID number to the feature and describe it in the Watercourses and Waterbodies Data Tables
	Peat bog	Peat bog and peat cuttings are symbolized as swamps, the areas are appropriately labeled.		Trace the boundaries of the peat bog on the overlay. Identify the outlined area with the symbol for wet areas. Assign an ID number to the feature and describe it in the Watercourses *and Waterbodies Data Tables*
Peat cuttings	Peat cuttings	Peat bog and peat cuttings are symbolized as swamps, the areas are appropriately labeled.		Same remarks as above. Also, identify peat cuttings with a special feature symbol, assign an ID number to the symbol and describe the cuttings in Data Table 3 — Watercourses and Waterbodies.
	Cranberry bog	A periodically flooded area in which cranberries are cultivated, the area is confined and subdivided by ditches or small levees. All separations are shown as perennial ditches.		Trace the boundaries of the cranberry bog on the overlay. Identify the outlined area with the symbol for wet areas. Assign an ID number to the feature and describe it in the Watercourses and Waterbodies Data Tables

TABLE 1 (CONTINUED) OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

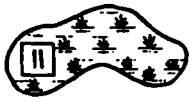
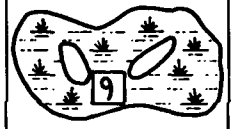
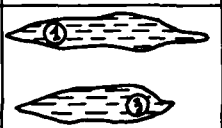
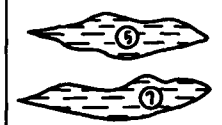
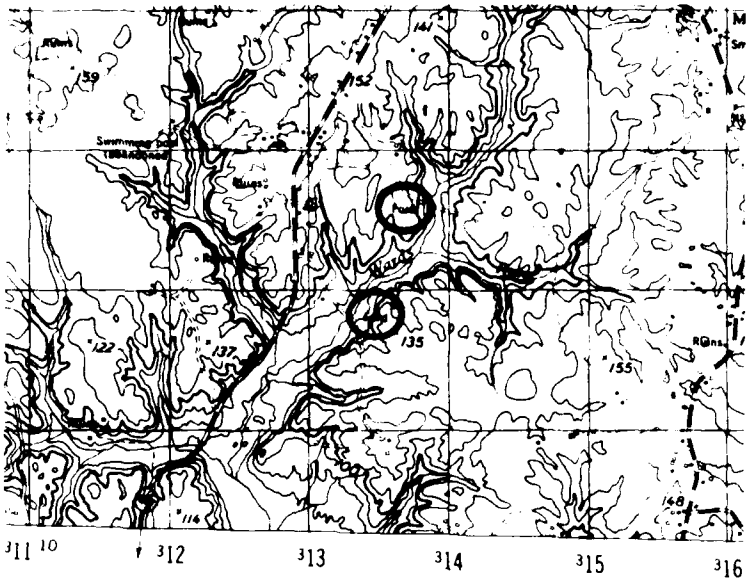
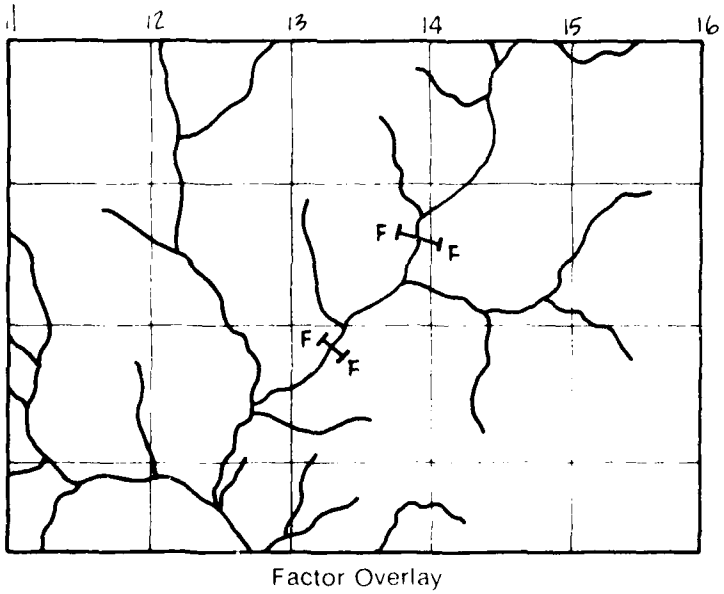
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Rice fields	Periodically flooded areas in which rice is grown; the areas are confined and subdivided by drainage ditches or small levees. Prominent leeves are symbolized as such; other separations are symbolized as perennial ditches.		Trace boundaries of the rice fields on the overlay. Identify the outlined area with the symbol for wet areas. When levees or ditches are present symbolize each with the appropriate symbol. Assign an ID number to each feature and describe them in the Watercourses and Waterbodies Data Tables
	Small clearings (hummocks, ridges, or dry areas)	Clearings are shown when they exceed approximately 0.10 inch (2.5mm) at their narrowest dimension.		Trace the boundaries of the small clearings on the overlay
	Land subject to controlled inundation	Land that is flooded by the regulation of the level of water impounded by a dam. Outer limits of the area are shown by a dashed line which represents the maximum extent of inundation.		Trace on the overlay, boundaries of the land subject to controlled inundation. Identify the outlined area with the symbol for special areas. Assign an ID number to the feature and describe it in Data Table 3 — Watercourses and Waterbodies
	Land subject to natural inundation	Land which is covered by water because of natural and periodic overflowing of a body of water. Also included are land areas which are constantly flooded year after year during rainy seasons.		Trace on the overlay, boundaries of of the land subject to natural inundation. Identify the outlined area with the symbol for areas subject to flooding. Assign an ID number to the feature and describe it in Data Table 3 Watercourses and Waterbodies

TABLE 1 (CONTINUED). OVERLAY REPRESENTATIONS OF U.S. INLAND HYDROGRAPHY SYMBOLS

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Mangrove	Mangrove is a thick impenetrable growth of trees with tangled aerial roots which appears in tropical and semitropical regions.		Trace boundaries of the area on the overlay. Identify the outlined area with the symbol for special areas. Assign an ID number to the feature & describe it in Data Table 3 - Watercourses and Waterbodies
	Nipa	Nipa is a dense growth of stemless palms found in tropical and semi-tropical tidal or brackish waters.		Trace boundaries of the area on the overlay. Identify the outlined area with the symbol for special areas. Assign an ID number to the feature and describe it in Data Table 3 - Watercourses and Waterbodies.
	Wet sand	Sandy areas in arid regions adjacent to coastal waters, the areas are continuously wet due to water seepage. The feature is labeled "wet sand" to differentiate it from a sebkha area.		Trace boundaries of the wet area on the overlay. Identify the outlined area with the symbol for a special area. Assign and ID number to the feature and describe it in Data Table 3 — Watercourses and Waterbodies
	Sebkha (kavir, etc.)	A flat plain of salt encrusted clayey soil which occurs in inland desert areas and adjacent to coastal waters in arid and semiarid regions. Is usually impassable to cross country movement.		Trace boundaries of the sebkha on the overlay. Identify the outlined area with the symbol for an area obstacle. Assign an ID number to the feature and describe it in Data Table 2 — Watercourses and Waterbodies



Topographic Map



Factor Overlay

Figure 4.4 Topographic Map and Factor Overlay of Same Area with Fords Symbolized.

Step 2. At each ford and ferry site, hand draft on the overlay the appropriate symbol in accordance with symbolization instructions in appendix A2.

4.2.1.4 Areas Subject to Flooding

Step 1. Follow the shorelines of all water bodies and watercourses shown on the topographic map. Pay particular attention to double line watercourses and large water bodies because land adjacent to these areas can be susceptible to natural inundation.

Step 2. When located, trace the boundary of each area on the overlay and symbolize as an area subject to flooding (figure 4.5).

Step 3. Hand draft the symbol for areas subject to flooding in accordance with appendix A2.

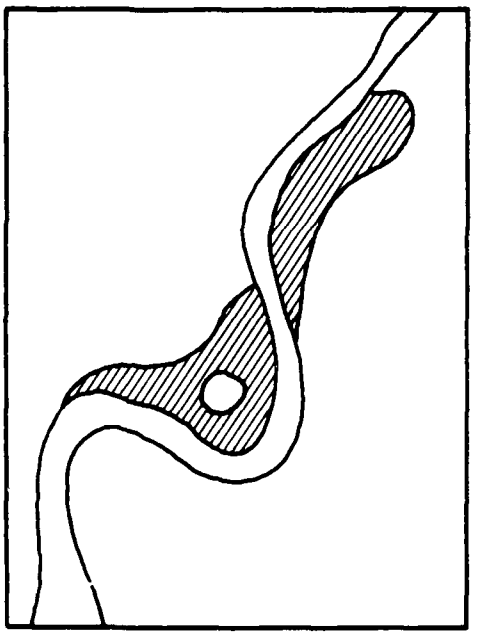


Figure 4 5 Map Overlay with Bound Areas Indicating Land Subject to Natural Inundation.

4.2.1.5 Point and Area Obstacles

Step 1. Starting in the upper left corner of the overlay and working across and down, systematically identify and symbolize all point and area obstacles (figure 4.6).

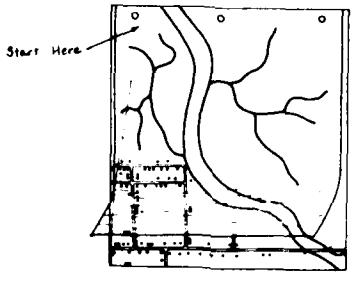


Figure 4.6 Point and Area Obstacle Identification.

Step 2. Review the coastal hydrography symbols for features that pose obstacles to waterborne movement. These features include, but are not limited to submerged breakwaters, exposed wrecks, and rocks awash. In each case, symbolize the feature on the overlay with a sketch of the appropriate coastal hydrography symbol* (see figure 4.7).

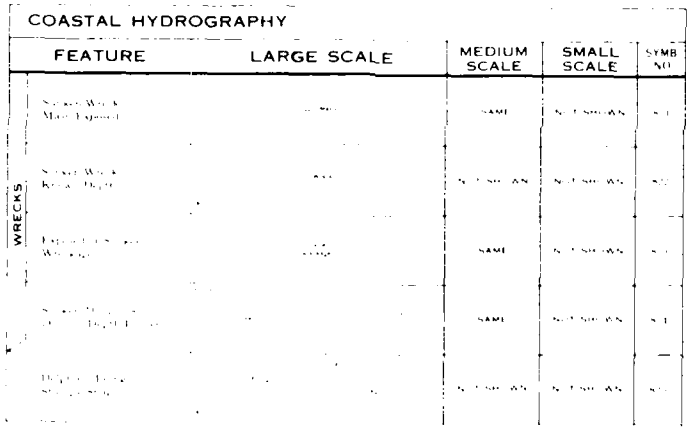


Figure 4.7 Coastal Hydrography Symbols.

*Defense Mapping Agency Hydrographic/Topographic Center, "Specifications for Military Maps", DMAHTC TM S-1, Ch. 6, Sect. 8.

Step 3. Symbolize area obstacles, such as Sebkha areas,* in accordance with symbolization instructions in appendix A2 (see figure 4.8).

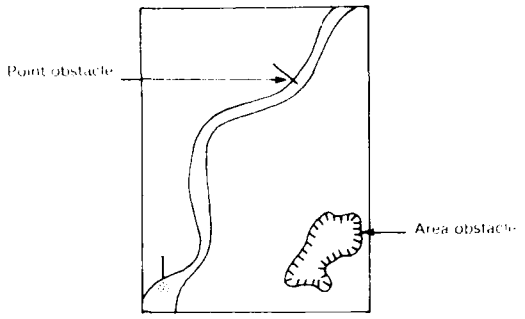


Figure 4.8 Point and Area Obstacle Symbolization.

4.2.1.6 Hydrologic Structures

Step 1. Record the position of hydrologic structures on the overlay. These structures include (1) bridges, (2) tunnels, (3) dams, (4) cable crossings, (5) levees and other flood control structures, and (6) locks, lifts, and other hydraulic structures.

Step 2. If doubt exists on how to symbolize a specific structure, consult Table 2. Overlay Representations of Miscellaneous Features.

Step 3. Hand draft the hydrologic structure symbols in accordance with appendix A2 (see figure 4.9).

*Sebkha areas are flat plains of salt-encrusted clayey soil that occur inland on desert areas, and adjacent to coastal waters in arid and semiarid regions.

TABLE 2. OVERLAY REPRESENTATIONS OF MISCELLANEOUS FEATURES

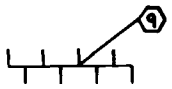
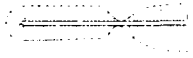
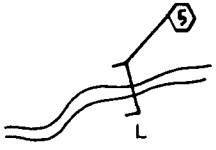
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Levee	Small levee where width of top of levee plots less than 0.3mm		Record the position of each levee with the overlay symbol for levees. Assign an ID number to each levee or series of levees and record each in Data Table 3 — Watercourses and Waterbodies under the heading "Structures and Special Features." Where possible, record map information on levee type, height, and width. Supplement with aerial photography.
	Levee	Large levee where plotted width of top of levee is 0.3mm or larger.		Same remarks as above.
	Masonry levee type features	These features include rip-rap slopes, dikes, fortification scarps etc.		Same remarks as above.
	Passable lock	The point of the lock symbol is shown pointing upstream.		Record the position of each lock with the overlay symbol for locks. Assign an ID number to each lock and record each in Data Table 3 — Watercourses and Waterbodies under the heading "Structures and Special Features."

TABLE 2 (CONTINUED). OVERLAY REPRESENTATIONS OF MISCELLANEOUS FEATURES

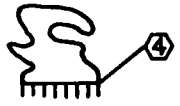
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Masonry dam, with vertical sides	If dam exceeds 0.4mm in width, it is plotted to scale		Record the position of each dam with the overlay symbol for dams. Assign an ID number to each dam structure and record each in Data Table 3 under the heading "Structures and Special Features." Where possible, record map information on dam type, height and width. Supplement with aerial photography.
	Masonry dam, with sloped sides	If sloped base of dam extends 0.75mm or more from the top of the dam, it is plotted to scale		Same remarks as above
	Masonry dam, with sloped sides	Sloped base of dam extends less than 0.75mm from the top of dam carrying road		Same remarks as above
	Earthen dam	Length of ticks (from top of levee to base) plotted to scale where longer than 0.4mm.		Same remarks as above

TABLE 2 (CONTINUED). OVERLAY REPRESENTATIONS OF MISCELLANEOUS FEATURES

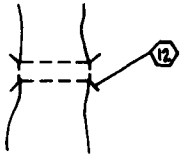
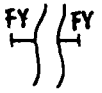
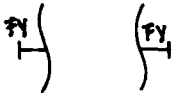
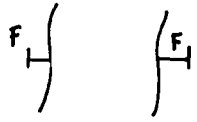
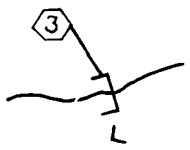
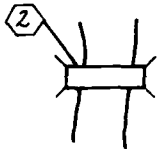
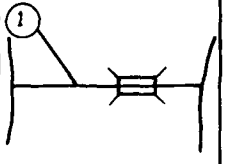
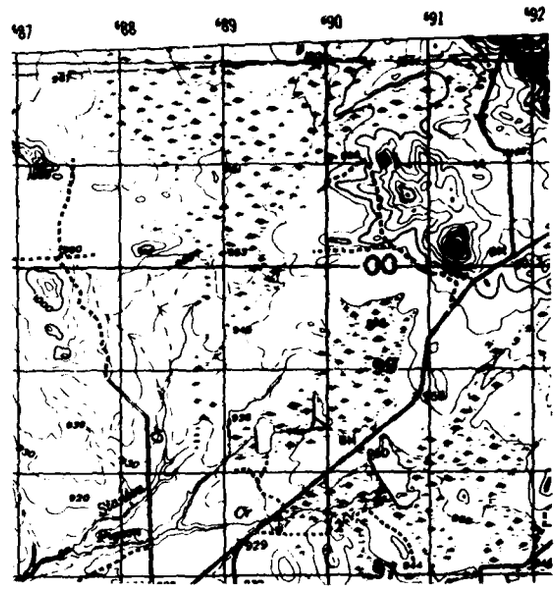
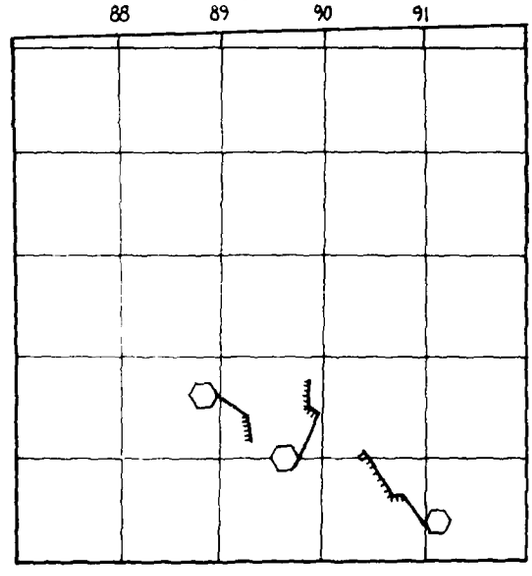
SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
	Highway tunnel	The minimum plotted size for any tunnel is 1.5mm. Tunnels that plot longer than the minimum size are plotted to scale		All types of tunnels, including highway tunnels and railroad tunnels have identical symbolization on the overlay. Describe/sketch each structure in Data Table 3 under the heading "Structures and Special Features"
Ferry	Ferry across narrow streams	Vehicular and railroad ferries are portrayed only when they are in regular operation for the purpose of transporting traffic between two points separated by water		Record the position of each ferry with the overlay symbol for ferries
Ferry	Ferry across open water	Same as above		Same remarks as above
Ford	Ford across narrow streams	Fords are shown where they relate to roads shown on the map		Record the position of each ford with the overlay symbol for fords
Ford	Ford across wide streams	Same as above		Same remarks as above

TABLE 2 (CONTINUED). OVERLAY REPRESENTATIONS OF MISCELLANEOUS FEATURES

SYMBOL	FEATURE	GENERAL CHARACTERISTICS	OVERLAY REPRESENTATION	REMARKS
Sluice gate	Canal lock or sluice gate	The point of the sluice symbol is shown pointing upstream.		Locks, lifts and other hydraulic structures have identical symbolization on the overlay. Describe/sketch each structure in Data Table 3 under the heading "Structures and Special Features".
	Highway bridge	Bridge symbols are usually representative in that their length must be exaggerated to legibly portray these features. The minimum plotted length for any bridge is 1.5mm.		All types of bridges, including highway bridges, railroad bridges, drawbridges, and footbridges have identical symbolization on the overlay. Where possible, record map information on bridge type and length in Data Table 3 under the heading "Structures and Special Features". Supplement with aerial photography.
Causeway	Causeway	A causeway is a constructed passageway for roads or railroads across open water. They may contain bridges to permit passage of boats.		Trace the alignment of the causeway on the overlay. Treat it as a special feature and describe/sketch it in Data Table 3 under the heading "Structures and Special Features".



Topographic Map



Factor Overlay

Figure 4.9 Topographic Map and Factor Overlay of Same Area with Hydrologic Structures Symbolized.

4.2.1.7 Special Features/Areas

Step 1. Starting in the upper left corner of the overlay and proceeding to the right and down, record the location of special features and areas. These are important hydrologic features and areas that do not fall into one of the factor overlay categories.

Step 2. Where map boundary lines delimit the feature or area of interest, retain these lines on the overlay. In some cases, boundary lines may be added to the features or areas of interest to delineate them clearly. Special features generally have point locations and include, but are not limited to gaging stations and navigation aids, such as towers and lighthouses. Special areas include, but are not limited to, natural or manmade structures, such as glaciers, sewage disposal and filtration beds, fishponds, and salt evaporation ponds.

Step 3. Hand draft the special feature and area symbols in accordance with appendix A2 (see figure 4.10).

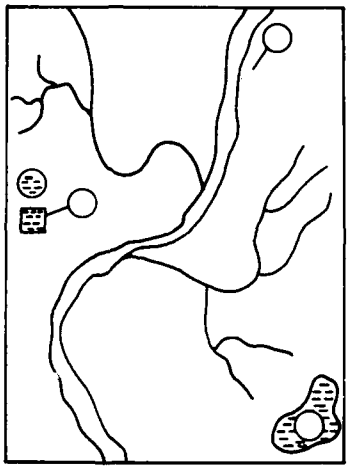


Figure 4.10 Map-derived Overlay with Special Features and Areas Symbolized.

4.2.1.8 Cross Section Sketches

Cross section information should be obtained after watercourse segments have been established (see sections 4.2.2.6-4.2.2.8).

Step 1. At selected locations on the watercourse, draw a line (profile line) approximately perpendicular to the direction of water flow (figure 4.11). Extend this line a sufficient distance on both banks of the watercourse to include at least the first break in slope above water level, and preferably well beyond that point. Cross section

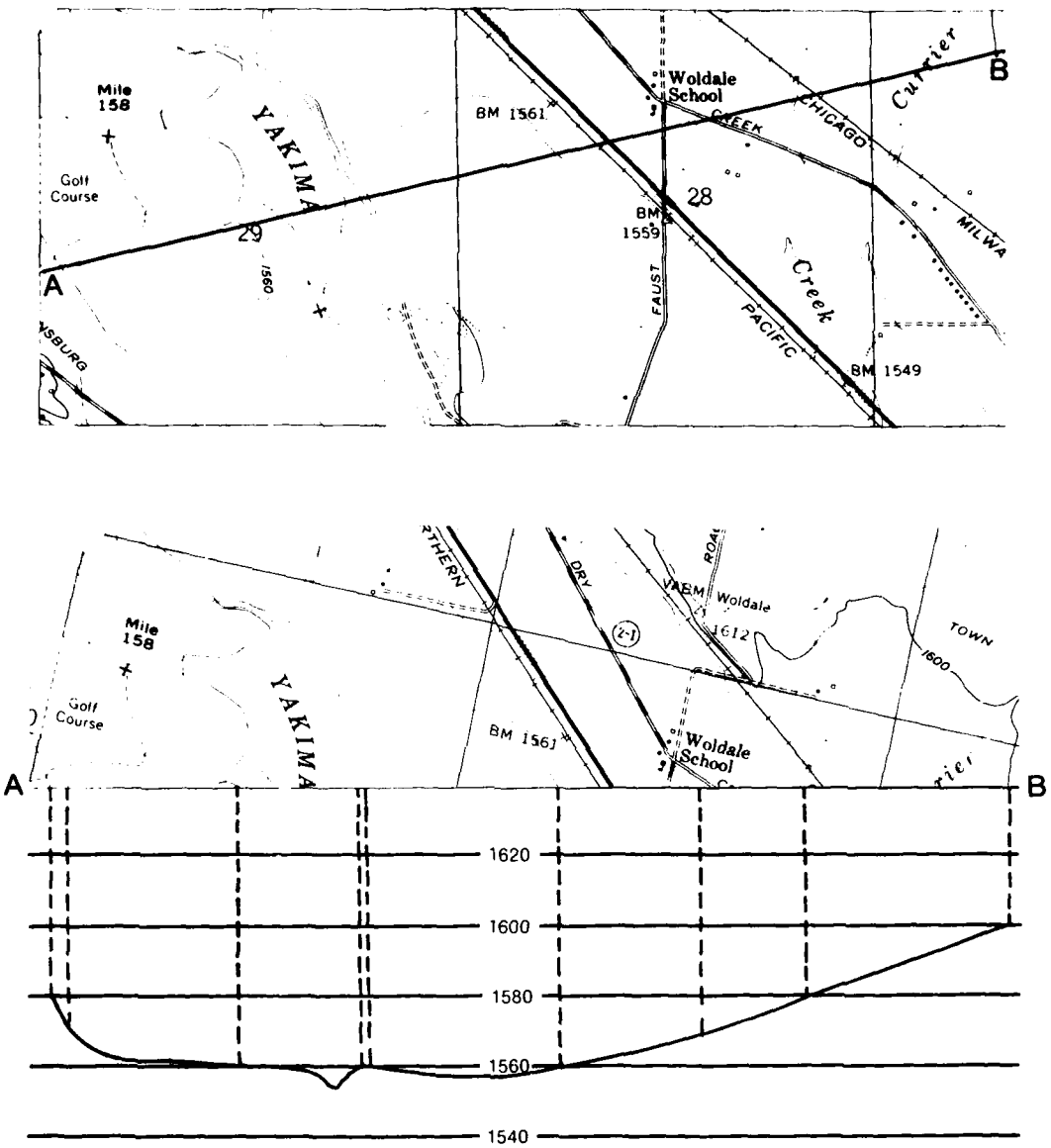


Figure 4.11 Drawing a Cross Section Sket h.

should be obtained primarily at points representing the average channel cross section for a given watercourse segment, or at any point where the channel radically changes shape.

Step 2. Use graph or blank paper for recording the cross section sketch. In the following steps, blank paper is used, although similar steps would be followed when using graph paper.

Step 3. Find the value of the highest and lowest contour lines that cross or touch the profile line. To ensure that elevation extremes along the profile will be shown, add one contour value above the highest, and one below the lowest, contour value.

Step 4. Draw equally spaced horizontal lines on a blank sheet of paper. Draw one line to represent each contour value determined in Step 3.

Step 5. Assign contour values to each of the equally spaced horizontal lines. To the top line, assign the highest value, to the bottom line, assign the lowest value. To the remainder of the lines, assign intermediate contour values in sequence.

Step 6. Place the lined (or graph) paper on the map with the horizontal lines adjacent and parallel to the profile line A-B (see figure 4.11).

Step 7. At every point where a contour line crosses or touches the profile line, drop an imaginary line perpendicular to the horizontal line having the same value as the contour line. Place a tick mark where the imaginary perpendicular crosses the horizontal line.

Step 8. Estimate the elevation of the highest and lowest points by interpolation. This is done by assuming that a constant slope gradient exists between adjacent contour lines. The elevation of an unknown contour point is therefore proportional to the horizontal distance (see example below).

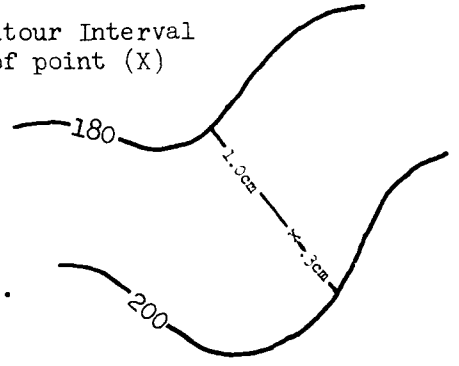
Given - 20 ft. Contour Interval
Find - Elevation of point (X)

Example:

$\frac{1.0}{1.3} = \frac{X}{20}$

X = 15.4 ft.

Elevation of point (X) = 195.4 ft.



Step 9. Connect all tick marks with a smooth natural curve because hills and valleys are usually rounded. The actual watercourse channel cross section must be estimated because its dimensions will not be resolved by commonly occurring contour intervals. Channel cross sections can usually be expected to approximate a V or U shape.

Step 10. Use a reflecting projector, or similar device, to project the cross section sketch onto the Cross Section Sketch column of Data Table 1 at an appropriate scale.

Step 11. Record the location of the cross section on the overlay with the cross section symbol. See appendix A2 for symbol dimensions.

Step 12. Assign an ID number to each cross section location on the overlay. Also, record this number next to the cross section sketch in Data Table 1.

4.2.1.9 Watercourse Slopes

Slope information should be obtained after watercourse segments have been established (see 4.2.2.6-4.2.2.8).

Step 1. Determine the change in elevation from the head (upstream limit) to the foot (downstream limit) of the watercourse segment of interest.

a. Estimate the elevation of the head of the watercourse segment. To accomplish this, use the interpolation method outlined in Step 8 of section 4.2.1.8.

b. Estimate the elevation of the foot of the watercourse segment.

c. Subtract the downstream limit value obtained in Step b. from the upstream limit value obtained in Step a.

Example:

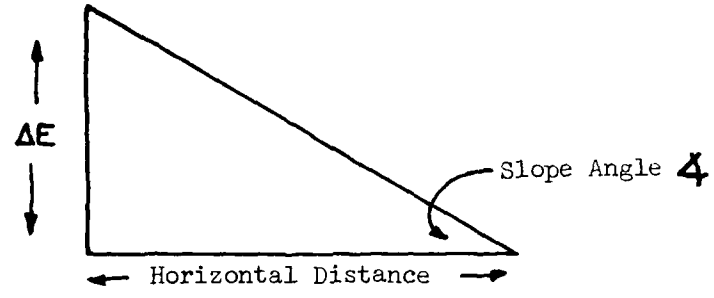
Change in Elevation (ΔE)= Upstream Limit Value - Downstream Limit Value

ΔE = 624 ft. - 459 ft.

ΔE = 165 ft.

Step 2. Determine the length of the watercourse segment of interest. To accomplish this, use the procedure outlined in Section 4.3.1.3.

Step 3. Use the change in elevation and watercourse segment horizontal distance information to calculate the watercourse slope angle.



Calculate the tangent of the watercourse slope angle.

Example:

$$\text{Tangent Slope } \measuredangle = \frac{\Delta E \text{ from Head to Foot of Watercourse Segment}}{\text{Watercourse Horizontal Distance}}$$

$$\text{Tangent Slope } \measuredangle = \frac{165 \text{ ft.}}{3960 \text{ ft.}}$$

$$\text{Tangent Slope } \measuredangle = .04167$$

Use a table of natural tangent values to determine the angle whose tangent most closely approximates the value calculated in this step.

Slope $\measuredangle = 2.3^{\circ}$ (From Table)

Step 4. Record the watercourse segment slope angle value in the "Slope in Degrees" column of Data Table 2.

4.2.2 Photo Analysis

4.2.2.1 Alinement of Watercourses and Water Body Shorelines

Step 1. Use Procedure 3 (4.5.3) to prepare a photo mosaic from alternate photos in each flightline (see figure 4.12).

The frosted mylar that is placed over the mosaicked photography is used for protecting the photos and as a medium or which notes can be recorded. All information will utimately be recorded on the map-derived (working) overlay and in the Hydrography Data Tables.

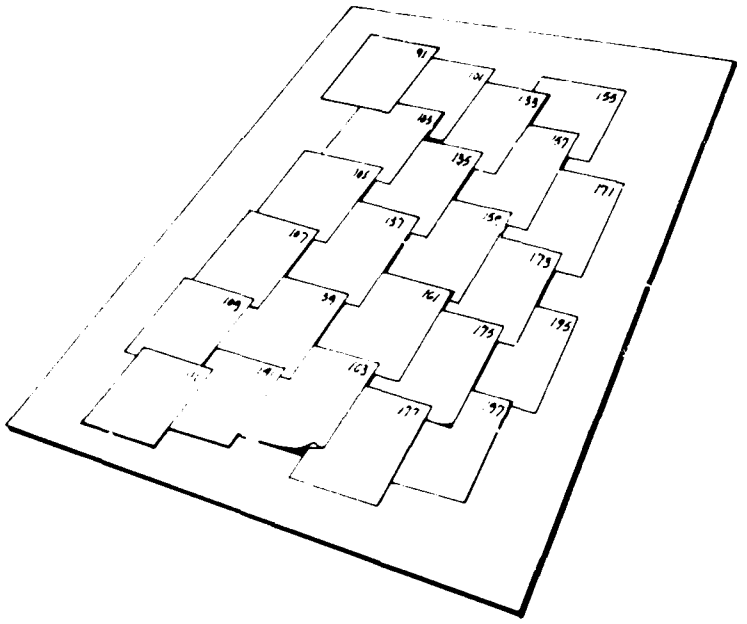


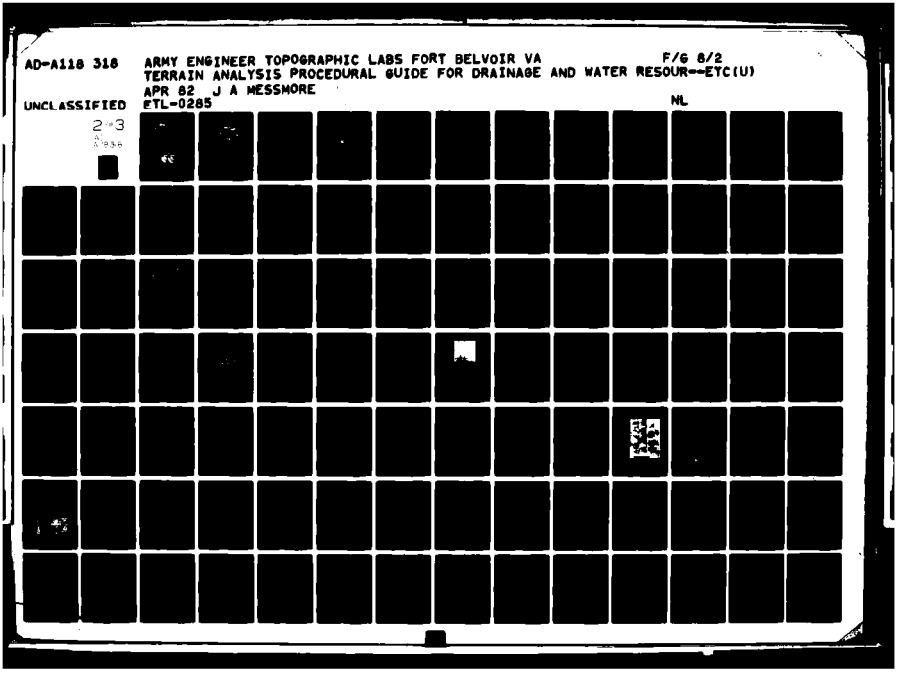
Figure 4.12 Arrangement of Alternate Photos.

Step 2. As required, refer to the photo mosaic and the overlay derived from the topographic map analysis (figures 4.13 and 4.14). Locate on the latter overlay all water bodies that are visible on the photos. As needed, consult stereograms 1 through 10 of this guide as well as appropriate portions of Engineer Intelligence Guide #32.* Where discrepancies between overlay and photos are found, trace the correct water body shorelines on the overlay material, and then transfer the information to the working overlay.

*U.S. Army Engineer Intelligence Guide, "Stream Fords and Structures," EIG 32.

AD-A118 318 ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA F/G 8/2
TERRAIN ANALYSIS PROCEDURAL GUIDE FOR DRAINAGE AND WATER RESOUR--ETC(U)
APR 82 J A MESSMORE

UNCLASSIFIED ETL-0285 NL



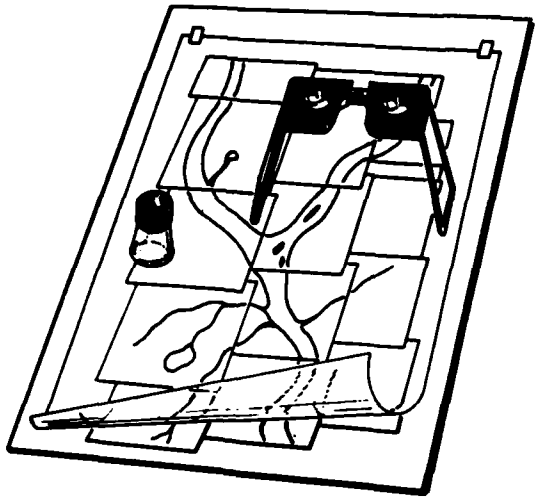


Figure 4.13 Photo Mosaic.

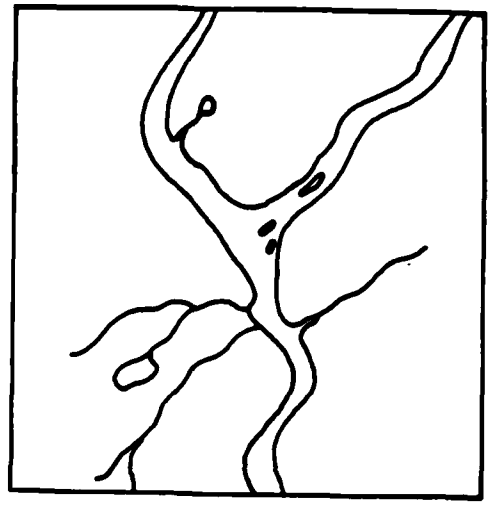


Figure 4.14 Map-derived Overlay.

Step 3. Use the photos to determine if the alinement of all watercourses, especially small obscure ones, have been included on the working overlay. Carefully study the furthest upstream portions of each watercourse, and determine if the watercourses inferred from contour lines are, in fact, probable watercourses. It may be necessary to erase some inferred watercourses and to add others not picked up in the map analysis. In densely wooded areas, where trees obscure vision to ground level, connect linear depressions in the forest canopy to estimate probable watercourse alinement (see figure 4.15).

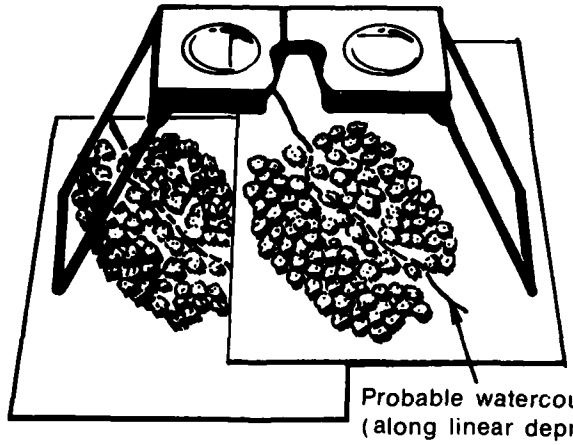


Figure 4.15 Method for Inferring Watercourse Alinement.

In other areas, watercourse alinement can be estimated from the fact that vegetation will often follow gully bottoms where more moisture is available. In these areas, estimate watercourse location by tracing the alinement of linear vegetation growth (see figure 4.16).

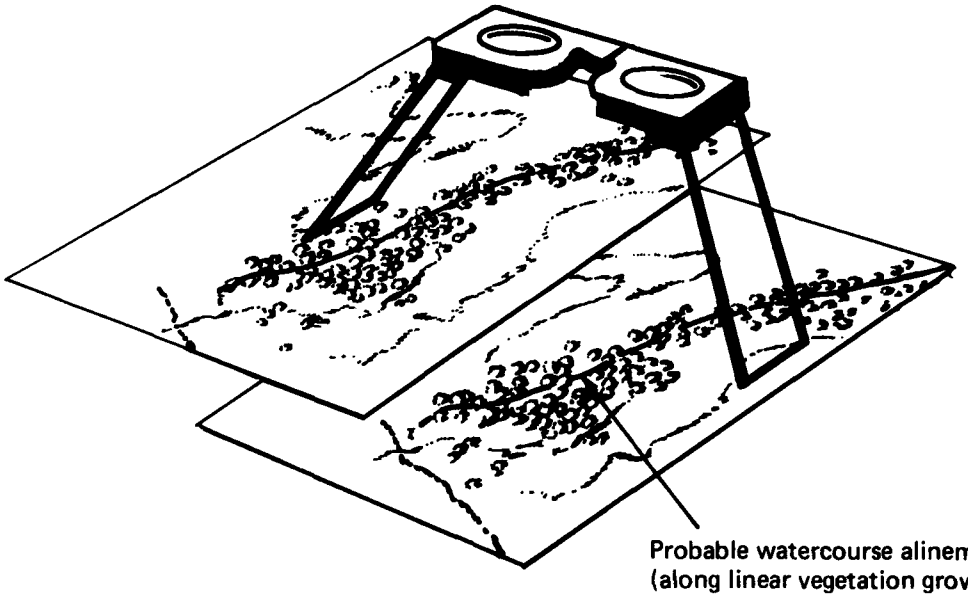


Figure 4.16 Alternate Method for Inferring Watercourse Alinement.

Step 4. Use Procedure 8 (4.5.8) to transfer photo-derived information on watercourse alinement to the working overlay.

4.2.2.2 Watercourse Gap Widths

Step 1. Use Procedure 5 (4.5.5) to determine the representative fraction of the aerial photography.

Step 2. Determine the locations where watercourse width class changes occur. Refer to the table below for width class change intervals.

Width Class	Intervals (meters)
1	0-3
11	3-10
111	10-18
1V	18-25

Width Class Cont.	Intervals (meters) Cont.
V	25-35
VI	35-50
VII	>50

(a) Start measurements at the furthest upstream portion of each watercourse.

(b) Use Procedure 6 (4.5.6) to measure dry gap distances. Background: Watercourse segments are based primarily on photo measured dry gap widths. This is the horizontal distance across a watercourse, bank to bank measured at the first slope break above mean water level (see figure 4.17).

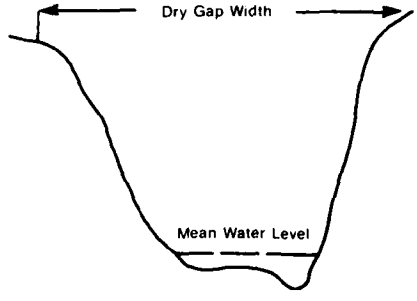


Figure 4.17 Watercourse Cross Section.

Step 3. On the photo overlay and the working overlay, record the locations of the width class transition points. Use the appropriate roman numeral from the preceding table to mark these locations. At each width class transition point, draw a line perpendicular to the watercourse, and add an arrow pointing upstream (see figure 4.18).

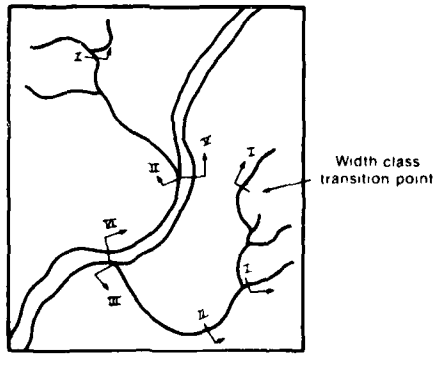


Figure 4.18 Working Overlay with Width Class Transition Points Indicated.

4.2.2.3 Watercourse Width Symbology

Step 1. For each width class segment 3 meters or greater in width, choose a segment location that appears to represent the average dry gap distance (see figure 4.19). Use Procedure 6 (4.5.6) to measure the dry gap distance at this point.

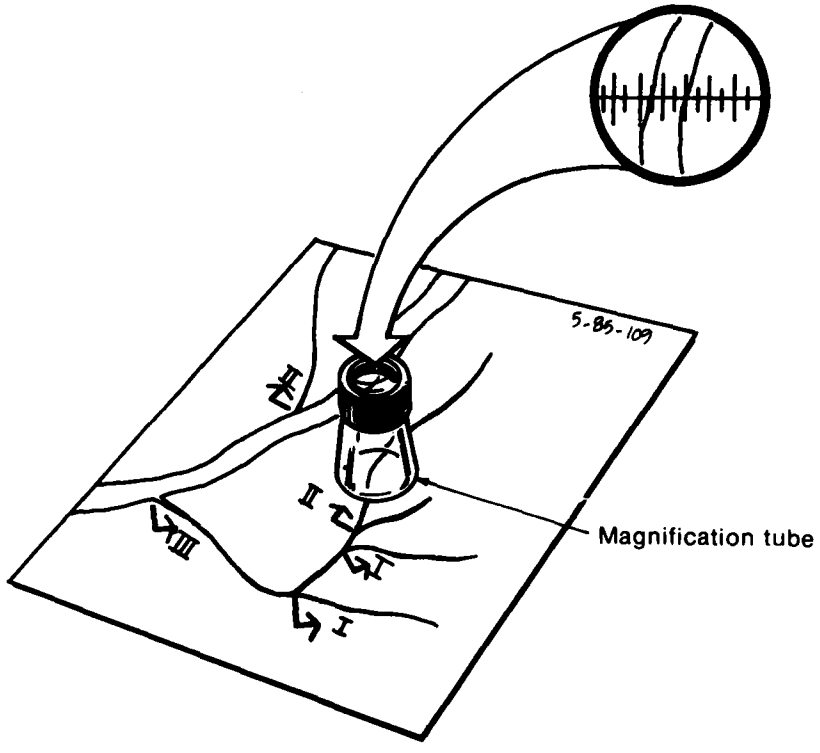


Figure 4.19 Selection of Location for Measurement of Average Dry Gap Distance.

Step 2. Record this value in pencil on the working overlay, adjacent to the watercourse, at the approximate location where the measurement was made (see figure 4.20).

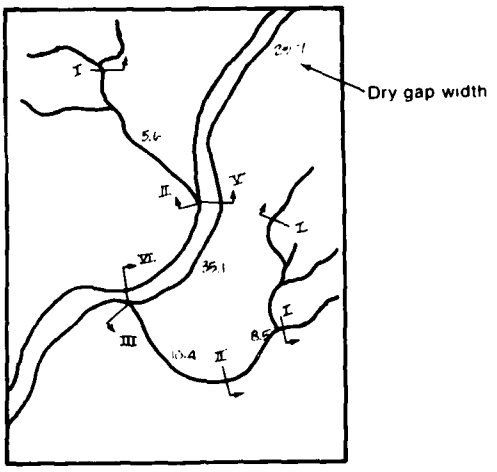


Figure 4.20 Working Overlay with Segment Dry Gap Widths Indicated.

Step 3. Starting with the furthest upstream segment of each watercourse, erase the original alinement symbology (as well as width class roman numeral and upstream arrow). At the same time, substitute the watercourse symbol that represents the measured gap width. Refer to the list below for appropriate symbology. Repeat this step for each watercourse segment that is less than 50 meters in width (figure 4.21).

Width Class	Gap Width (m)	Symbol
1	<3	
11	3-10	
111	10-18	
1V	18-25	
V	25-35	
V1	35-50	
V	>50	(drawn to scale)

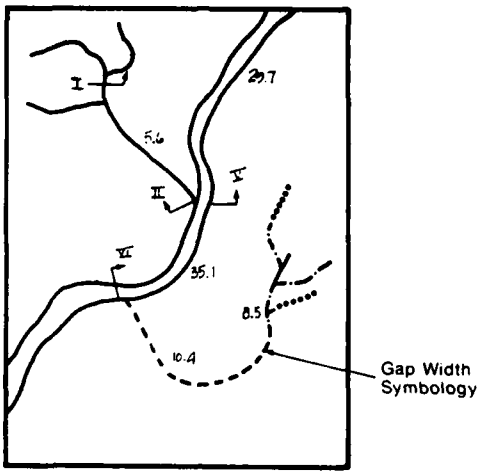


Figure 4.21 Working Overlay with Original Symbology Partially Replaced by Appropriate Gap Width Symbology.

4.2.2.4 Watercourse Terminal Points

Step 1. Assign the watercourse terminal point symbol to each watercourse 3 meters or greater in width where it crosses the map neatline (see figure 4.22). Refer to appendix A2 for dimensions of the terminal point symbol.

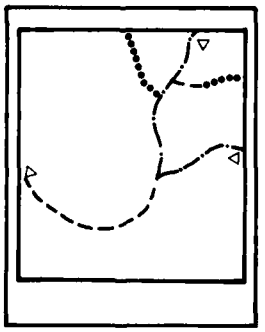


Figure 4.22 Working Overlay with Terminal Point Symbols Where Watercourses 3 meters or Greater in Width Cross the Map Neatline.

Step 2. Assign the watercourse terminal point symbol to each watercourse where the dry gap becomes 3 meters or greater in width (see figure 4.23).

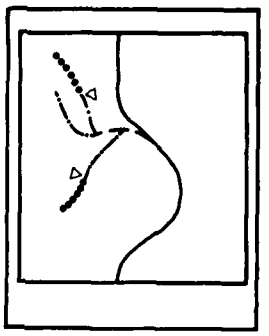


Figure 4.23 Working Overlay with Terminal Point Symbols Where the Watercourse Dry Gap Becomes 3 meters or Greater in Width.

Step 3. Assign the watercourse terminal point symbol to locations where the watercourse loses its identity by entering a water body or larger watercourse, or where the watercourse regains its identity by emerging below a dam. Refer to information on the 1:50,000 topographic map to locate watercourse end points (see figure 4.24).

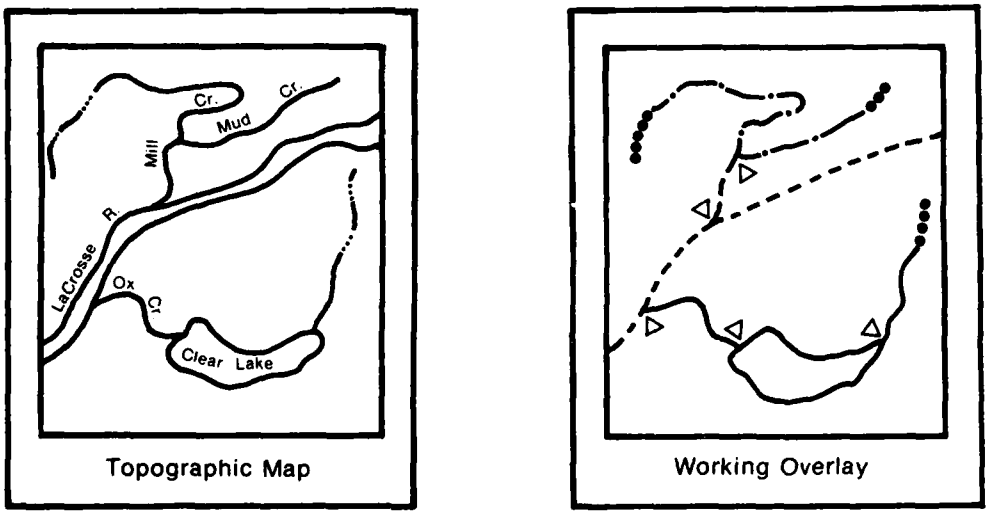


Figure 4.24 Topographic Map and Corresponding Working Overlay with Watercourse Terminal Points Indicated.

4.2.2.5 Classification of Water Bodies, Watercourses, and Wet Areas

Step 1. Establish stereo vision by using, as needed, the alternate photos not used in composing the mosaic.

Step 2. Systematically study each photo in the mosaic.

Step 3. Compare the working overlay with the photo mosaic to determine if all watercourses, water bodies, and wet areas occurring on the photos are recorded on the overlay.

The image characteristics of water bodies, watercourses, and wet areas can vary greatly and are dependent upon various factors including the incidence angle of reflected sunlight, photo scale, season of the year, meteorological conditions, etc. Because of this variability, the image characteristics of identifiable water bodies, watercourses, and wet areas should be studied stereoscopically, looking for areas with similar characteristics on the photos that have not been recorded on the overlay. Consult stereograms 1 through 10 of this guide as well as Engineer Intelligence Guide #32* for additional information on this subject.

Review Table 1. Overlay Representations of U.S. Inland Hydrography Symbols to become familiar with the features classified as wet areas. Swamps and marshes are often the most obvious features, although many other features are also symbolized as wet areas on the overlay.

Step 4. When discrepancies are found between the working overlay and the photo mosaic, transfer the unrecorded information to the overlay. Use the appropriate symbol from appendix A2.

Step 5. Number each water body, watercourse, and wet area consecutively, starting in the upper left corner of the overlay. Progress to the right and down the overlay in a normal reading manner (see figure 4.25).

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*U.S. Army Engineer Intelligence Guide, "Stream Hydrology and Hydraulic Structures," EIG32, pp. 4-14.

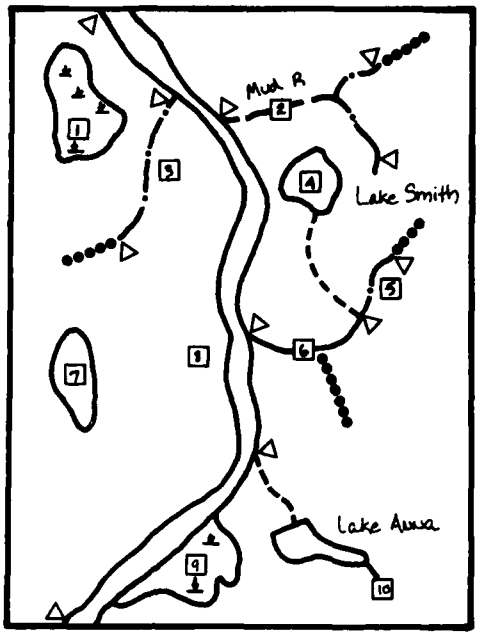


Figure 4.25 Working Overlay with ID Numbers Assigned to All Water Bodies, Watercourses and Wet Areas.

Step 6. Record the ID number in the first column of the Hydrography Data Tables 1 to 3 (see figure 4.26).

Step 7. Identify each feature by local name, if known, and classify each into one of the following hydrologic classes (see Glossary for definition of terms):

Hydrologic Classes

River
Stream
Inland Waterway
Aqueduct, Penstock, Pipeline, Flume
Canal (navigable, abandoned, under construction)
Irrigation Canal/Ditch
Drainage Canal/Ditch
Lake
Pond
Inland Sea
Marsh
Swamp

Paddy/Wet Crops
Salt Pan
Reservoir (includes under construction and normally dry, flood control reservoirs)
Lagoon

Step 8. Record the local name and classification information in the appropriate columns of each Hydrography Data Table (see figure 4.26).

HYDROGRAPHIC FEATURE			
ID NO	LOCAL NAME	CLASS	SEG NO
1	Nous	Swamp	
2	Mud River	River	
3	Wells Creek	Stream	
4	Lake Smith	Lake	

Note. Data taken from Figure 4.25.

Figure 4.26 A Portion of Data Table 1 – Watercourses and Water Bodies.

4.2.2.6 Watercourse Segment Start/End Points

4.2.2.6.1 Watercourses with dry gap widths of 50m or less.

Select segments primarily on the basis of watercourse width. When known, extreme changes in bank, depth, bottom, or velocity conditions may also be reasons for selecting segments. Refer to the working overlay and the photo mosaic as necessary while performing the following steps:

Step 1. Begin with the furthest upstream portion of each watercourse with dry gap widths of 50m or less depicted on the working overlay. Use the watercourse start/end point symbol to mark the location where the first width class transition point occurs downstream from the watercourse terminal points marked previously (see figure 4.27)

Step 2. Refer to appendix A2 for symbol dimensions.

Step 3. Progress downstream and mark the location of each successive width class transition point with a watercourse segment start/end point symbol.

Step 4. Repeat steps 1 thru 3 until watercourse segments have been established on all watercourses with dry gap widths of 50m or less.

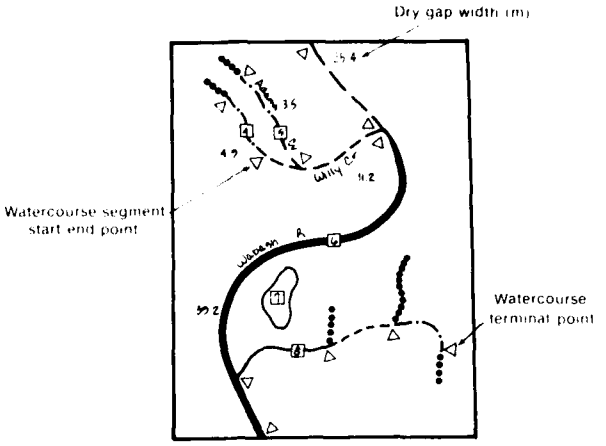


Figure 4.27 Working Overlay with Segment End Points Established Where Width Class Transitions Occur.

4.2.2.6.2 Watercourses with dry gap widths of greater than 50m.

Select segments on the basis of bank height. Establish a separate series of segments for each side of the watercourse.

Step 1. If not done previously, use Procedure 5 (4.5.5) to calculate the representative fraction of the photography.

Step 2. Establish stereo vision by using, as needed, the alternate photos not used in composing the mosaic. Securely fasten the stereo mate (alternate photo) to acetate, overlaying the photo mosaic.

Step 3. Refer to the photos and map to establish a reference point from which to begin bank height measurements. The reference point may be where the watercourse crosses the map neatline, where it becomes greater than 50m in width, or where it emerges below a water body.

Step 4. At the reference point established in Step 3, use Procedure 7 (4.5.7) to measure the vertical distance in meters between the water's edge and the top of the right watercourse bank. (Right bank is that bank on your right while facing downstream).

Step 5. Record this value to the nearest tenth of a meter on the working overlay, adjacent to the watercourse, in the approximate location where the measurement was made (see figure 4.28).

Step 6. Determine the location downstream where the bank height differs from the first measurement by ±1.0 m.

Step 7. Mark that point on the working overlay with a segment start/end point symbol.

Step 8. Measure and mark subsequent downstream segments as described in steps 6 and 7.

Step 9. Establish a separate series of segments for the opposite (left) side of the watercourse.

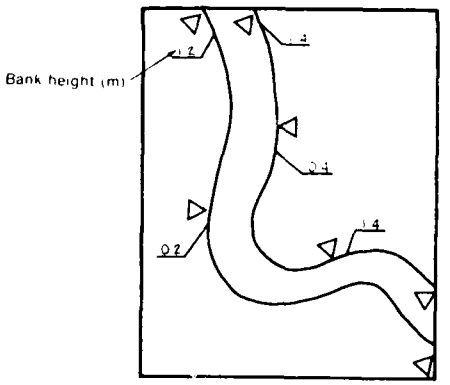


Figure 4.28 Working Overlay with Separate Series of Segments Established on Each Watercourse Bank.

4.2.2.7 Water Body Shore Segment Start/End Points

Refer to the working overlay and photo mosaic as necessary while performing the following steps:

Step 1. Establish shore segments on the basis of bank heights. Stereoscopically examine the shoreline of each water body on the photos. Select a suitable shoreline reference point from which to begin bank height measurements.

Step 2. At the reference point established in Step 2, use Procedure 7 (4.5.7) to measure the vertical distance between the water's edge and the top of the bank to the nearest tenth of a meter.

Step 3. Record this value on the working overlay, adjacent to the water body shoreline, in the approximate location where the measurement was made (see figure 4.29).

Step 4. Mark the location of the reference measurement on the working overlay with a segment start/end point symbol. Darken the center portion of this symbol to distinguish it from subsequent start/end point symbols as shown in figure 4.29.

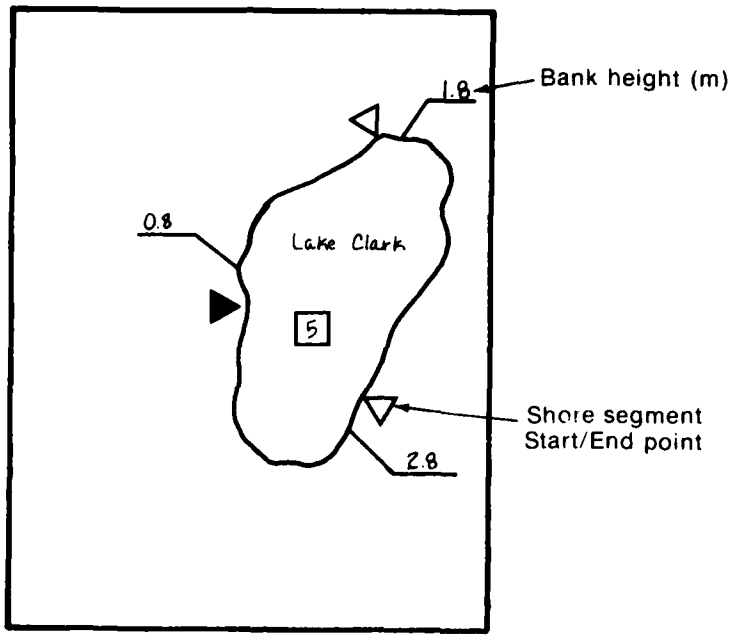


Figure 4.29 Working Overlay with Shore Segment Start/End Points and Bank Heights Indicated.

Step 5. Continue around the water body clockwise, and determine the point on the shoreline where the bank height differs from the first measurement by $\pm$1.0 m. Mark this location on the overlay with a segment start/end point symbol.

Step 6. Record the bank height value to the nearest tenth of a meter on the overlay adjacent to the segment start/end point symbol.

Step 7. Measure and mark subsequent bank segments in the same manner.

NOTE: In the case where there is high topographic relief along the shoreline, segments based upon 1-meter-height increments may be impractical. When the bank height changes rapidly, segments may be based upon multiples of the 1-meter-height increments, e.g. 2 m, 3 m. This should be done only where steep slopes prevent the use of 1-meter increments (see figure 4.30).

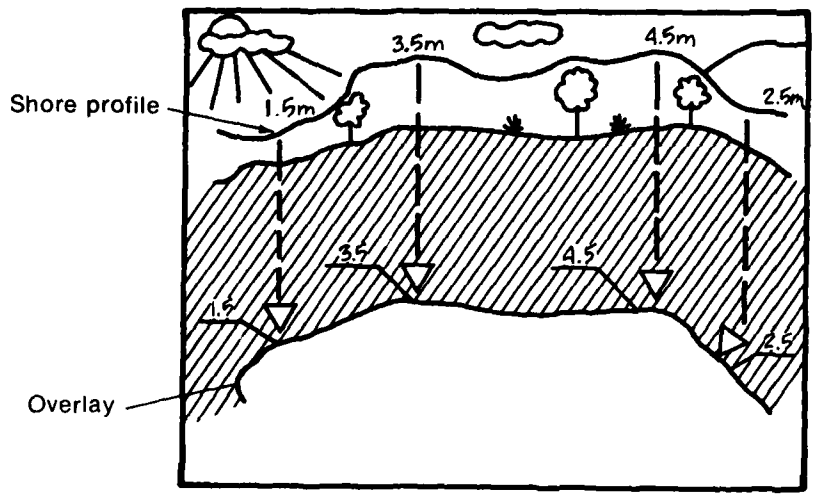


Figure 4.30 Shore Profile Above with Segments Established on the Overlay Below.

4.2.2.8 Segment Identification

4.2.2.8.1 Watercourses with dry gap widths of 50m or less.

Step 1. Assign a lower case segment identification letter, e.g. a, b, to each watercourse segment on the overlay. If more than 26 segments are assigned on any one watercourse, use aa, bb for subsequent segments.

a. Assign the letter "a" to the first segment downstream from the watercourse terminal point symbol.

b. Assign the letter "b" to the next downstream segment. Continue to assign a letter to subsequent downstream segments until each segment has been assigned an identification letter (see figure 4.31).

Step 2. Refer to appendix A2 for dimensions of segment identification letters.

Step 3. Record each assigned segment letter in the appropriate column of Data Tables 1 to 3 (see figure 4.32).

Step 4. Determine the average bank height for both the right and left banks of each segment.

Refer to the working overlay and the photo mosaic as necessary while performing the following 6 steps.

1. Establish stereo vision by using, as needed, the alternate photos not used in composing the mosaic. Securely fasten the stereo mate (alternate photo) to acetate, overlaying the photo mosaic.

2. Use available landmarks on the map and photos to locate the watercourse segment of interest.

3. Study the segment stereoscopically and pick a point on the right bank that appears to represent the average height of the bank.

4. Use Procedure 7 (4.5.7) to measure the vertical distance in meters between the water's edge and the top of the watercourse bank.

5. Record this value to the nearest tenth of a meter in Data Table 1 under "Right Bank" (see figure 4.32).

6. Repeat 3 and 4 in step 4 for the left bank and record the bank height in Data Table 1 under "Left Bank".

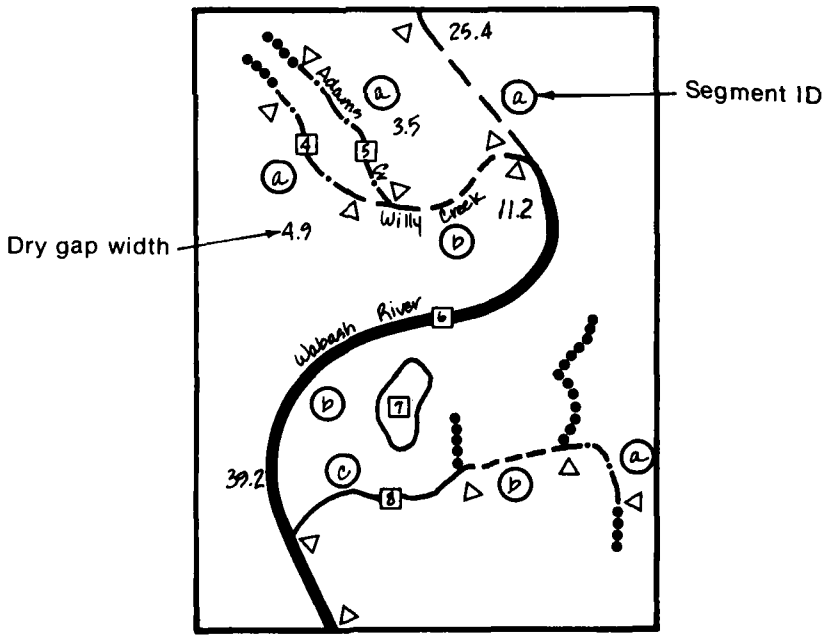


Figure 4.31 Working Overlay with ID Letters Assigned to Watercourse Segments.

HYDROGRAPHIC FEATURE				DRY GAP WIDTH IN METERS	SEAS HIGH
ID NO	LOCAL NAME	CLASS	SEG LETTER		MONTH(S)
4	Willy Creek	Stream	a	49	Dec-Feb
			b	112	Dec-Feb
5	Adams Creek	Stream	a	35	Apr
6	Wabash River	River	a	254	Apr
			b	39.2	
7	Lake Clark	Lake	a		Apr
			b		
			c		

BANK INFORMATION					
RIGHT BANK			LEFT BANK		
HEIGHT IN METERS	SLOPE IN DEGREES MIN MAX	MATERIAL	HEIGHT IN METERS	SLOPE IN DEGREES MIN MAX	MATERIAL
0.9			1.2		
1.4			2.1		
1.1			1.3		
2.1			2.4		
1.5			1.8		
0.8					
1.8					
2.8					

Note: Data taken from Figures 4.29 and 4.31.

Figure 4.32 A Portion of Data Table 1 with Segment Letters, Bank Heights, and Dry Gap Widths Recorded.

4.2.2.8.2 Watercourses with dry gap widths of greater than 50 m.

Double-line watercourses require a separate series of ID letters for each bank.

Step 1. Assign the ID letter "a" to the furthest upstream right bank segment. The right bank is on your right when facing downstream.

Step 2. Assign the letter "b" to the next downstream segment. Continue to assign a letter to subsequent downstream segments until each segment has been assigned an ID letter.

Step 3. Repeat steps 1 and 2 on the left watercourse bank.

Step 4. Record each assigned segment letter in the appropriate column of Data Tables 1 to 3. In Data Table 1, also record each segment's bank height. Be sure to record right bank heights under "Right Bank" and left bank heights under "Left Bank."

4.2.2.8.3 Water Bodies

Step 1. For each water body on the overlay, assign the ID letter "a" to the first bank segment clockwise from the darkened start/end point symbol.

Step 2. Erase the darkened center portion of the symbol used in Step 1.

Step 3. Proceed clockwise and assign the ID letter "b" to the adjacent bank segment.

Step 4. Continue around the water body clockwise until each bank segment has been assigned an ID letter (see figure 4.33).

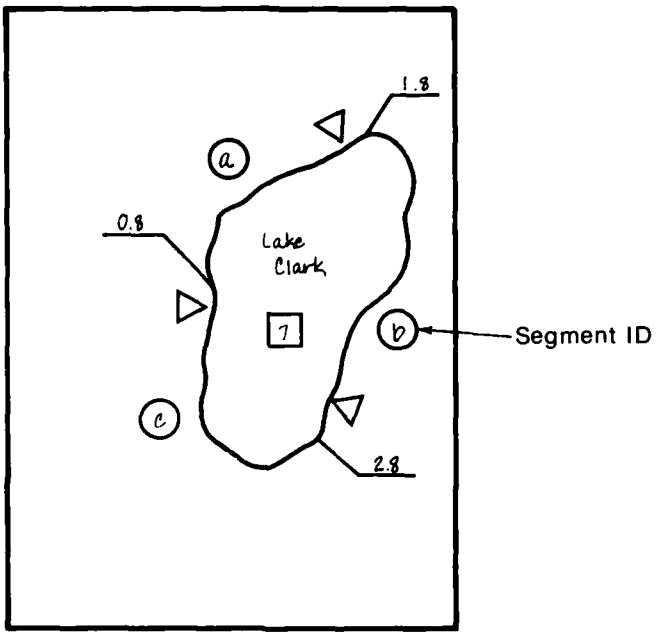


Figure 4.33 Working Overlay with ID Letters Assigned to Water Body Segments.

Step 5. Record each assigned segment letter in the appropriate column of Data Tables 1 to 3. In Data Table 1, also record each segment's bank height under "Right Bank" as shown in figure 4.32.

4.2.2.9 Segment Bank Slopes

4.2.2.9.1 Watercourses with dry gap widths of less than 50 m.

Step 1. Determine the minimum and maximum bank slope in degrees for both the right and left banks of each watercourse segment.

a. Use available landmarks on the map and photos to locate each watercourse segment of interest.

b. Stereoscopically examine each segment and determine the location of minimum and maximum slopes for both the right and left banks.

c. At each point, use Procedure 7 (4.5.7) to measure the vertical distance (h) between the water level and the top of the bank (see figure 4.34).

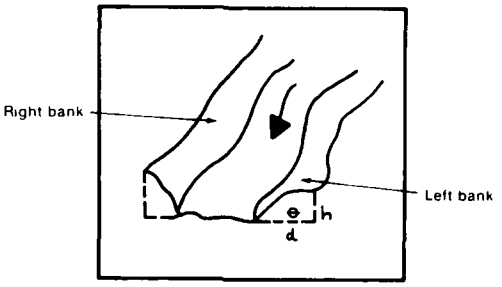


Figure 4.34 Cross Section of Left and Right Watercourse Banks.

d. At each point, use Procedure 6 (4.5.6) to measure the horizontal distance between the water's edge and the top of the watercourse bank. This distance will correspond approximately to the true horizontal distance (d) as shown in figure 4.34.

e. Compute bank slope (Θ) in degrees by substituting the horizontal distance (d) and bank height (h) into the equation:

$$\text{Tangent } \Theta = \frac{h}{d}$$

Example: h = 1.6m
d = 2.6m

Substitute h and d into the equation and solve for tan Θ.

$$\tan \Theta = \frac{1.6}{2.6}$$

$$\tan \Theta = 0.6154$$

Match the calculated tan Θ value (0.6154) with the natural tangent value it most closely approximates (see figure 4.35).

Natural Sines, Cosines and Tangents

Degs.	Function	0.0°	0.1°	0.2°	0.3°	0.4°	0.5°	0.6°	0.7°	0.8°	0.9°
30	sin	0.5000	0.5015	0.5030	0.5045	0.5060	0.5075	0.5090	0.5105	0.8415	0.5135
	cos	0.8660	0.8652	0.8643	0.8634	0.8625	0.8616	0.8607	0.8599	0.8590	0.8581
	tan	0.5774	0.5797	0.5820	0.5844	0.5867	0.5890	0.5914	0.5938	0.5961	0.5985
31	sin	0.5150	0.5165	0.5180	0.5195	0.5210	0.5225	0.5240	0.5255	0.5270	0.5284
	cos	0.8572	0.8563	0.8554	0.8545	0.8536	0.8326	0.8517	0.8508	0.8499	0.8490
	tan	0.6009	0.6032	0.6056	0.6080	0.6104	0.6128	0.6152	0.6176	0.6200	0.6224
32	sin	0.5299	0.5314	0.5329	0.5344	0.5358	0.5373	0.5388	0.5402	0.5417	0.5432
	cos	0.8480	0.8471	0.8462	0.8453	0.8443	0.8434	0.8425	0.5120	0.8406	0.8396
	tan	0.6249	0.6273	0.6297	0.6322	0.6346	0.6371	0.6395	0.6420	0.6445	0.6469
33	sin	0.5446	0.5461	0.5476	0.5490	0.5505	0.5519	0.5534	0.5548	0.5563	0.5577
	cos	0.8387	0.8377	0.8368	0.8358	0.8348	0.8339	0.8329	0.8320	0.8310	0.8300
	tan	0.6494	0.6519	0.6544	0.6569	0.6594	0.6619	0.6644	0.6669	0.6694	0.6720

Figure 4.35 Table of Natural Sines, Cosines and Tangents.

The table value of 0.6152 most closely matches the calculated tangent value and corresponds to an angle of 31.6°.

Round off the angle to the nearest whole degree (31.6° rounds off to 32°).

Step 2. Record the calculated minimum and maximum bank slope values in Data Table 1 as shown in figure 4.36.

HYDROGRAPHIC FEATURE				DRY GAP WIDTH IN METERS	BANK INFORMATION						MAX DISCHARGE cu m/s
					RIGHT BANK			LEFT BANK			
ID NO	LOCAL NAME	CLASS	SEG LETTER		HEIGHT IN METERS	SLOPE IN DEGREES MIN/MAX	MATERIAL	HEIGHT IN METERS	SLOPE IN DEGREES MIN/MAX	MATERIAL	
1	Pohick Creek	Stream	a	8.1	2.0	15/31	GC-GM	1.5	10/32	GW.GP	740
			b	12.4	3.0	13/19	CM Stone	2.0	9/20	SMCL	740

Figure 4.36 A Portion of Data Table 1 – Watercourses and Water Bodies.

4.2.2.9.2 Watercourses with dry gap widths of 50 m or greater and prominent water bodies.

Step 1. Determine the minimum and maximum bank slope in degrees for each bank segment.

a. Use available landmarks on the map and photos to locate each bank segment of interest.

b. Stereoscopically examine each bank segment and determine the locations of minimum and maximum slope.

c. Compute bank slopes as outlined previously in section 4.2.2.9.1, step 1.

Step 2. Record the calculated minimum and maximum bank slope values on the working overlay and in Data Table 1 (see figures 4.37 and 4.38).

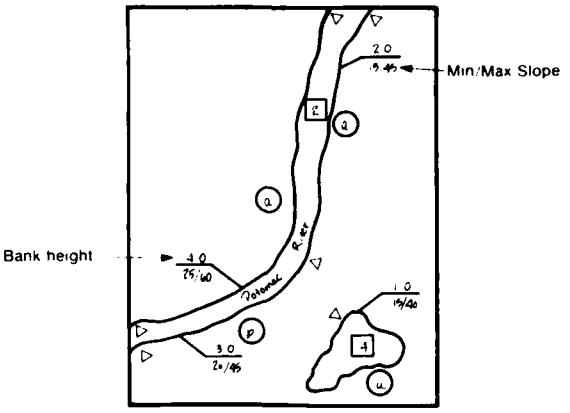


Figure 4.37 Working Overlay with Bank Heights and Min/Max Slopes Recorded.

HYDROGRAPHIC FEATURE				DRY GAP WIDTH IN METERS	BANK INFORMATION					
					RIGHT BANK			LEFT BANK		
ID NO	LOCAL NAME	CLASS	SEG LETTER		HEIGHT IN METER	SLOPE IN FORCE MIN/MAX	MATERIAL	HEIGHT IN METER	SLOPE IN FORCE MIN/MAX	MATERIAL
1	Pohick Creek	Stream	a	8 1	2 0	15/31	GC - GM	1 5	10/32	GW. GP
			b	12 4	3 0	13/19	CM Stone	2 0	5/20	SMCL
2	Potomac River	River	a	2500 0	4 0	25/60	Rock	—	—	—
			a	2500 0	—	—	—	2 0	.5/45	SC
			b	26000	—	—	—	3 0	20/45	SC
3	Great Swamp	Swamp	—	—	—	—	—	—	—	—
4	Walden Pond	Pond	a	20.0	1 0	15/40	CM	—	—	—

Note: Data taken from Figure 4.37.

Figure 4.38 A Portion of Data Table 1 – Watercourses and Water Bodies.

Step 3. When necessary, use the Slope Conversion Scale (figure 4.39) to convert bank slope in degrees to percent slope.

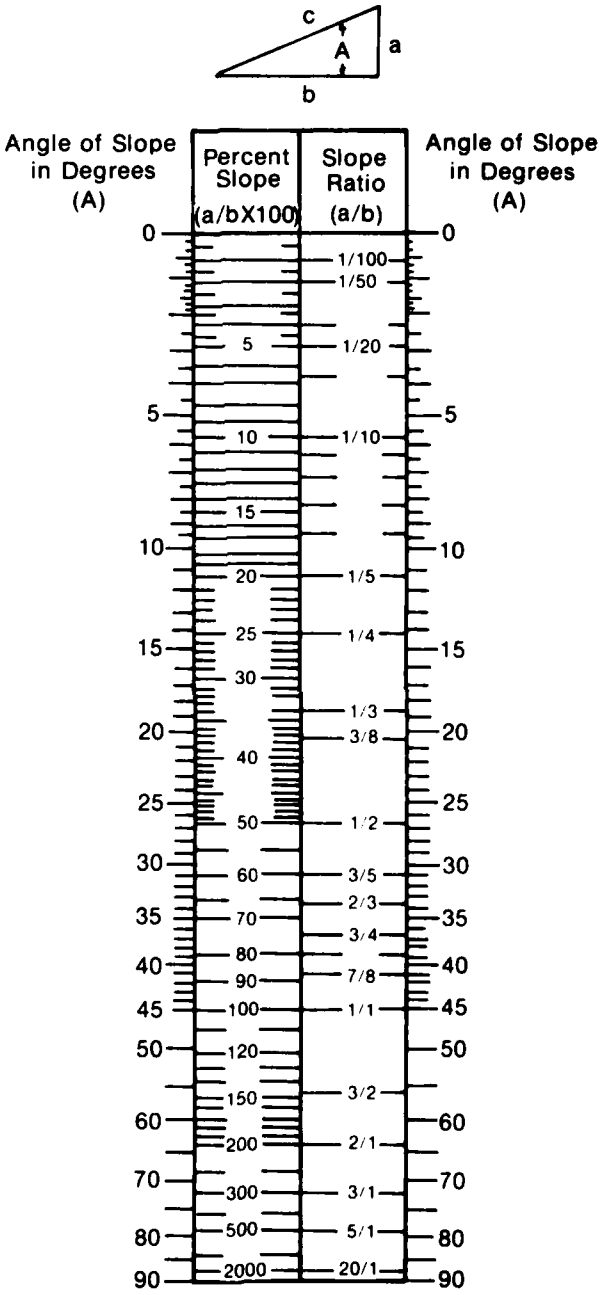


Figure 4.39 Slope Conversion Scale.

4.2.2.10 Areas Subject to Flooding

Step 1. Stereoscopically examine each photograph in the mosaic and determine if flooded areas are present.* These areas will usually occur along existing watercourses and water bodies, or in localized topographic depressions. Clues to the location of probable flooded areas include submerged or partially submerged cultural features such as buildings, roads, cultivated crops, and fence rows.

Step 2. When a flooded area appears on the photography and not on the topographic map, trace the boundaries of the unrecorded flooded area on the working overlay.

Step 3. Refer to appendix A2 for symbol dimensions.

Step 4. Number each area subject to flooding consecutively, starting in the upper left corner of the overlay. Progress to the right and down the overlay in a normal reading manner.

Step 5. Record these ID numbers in Data Table 3 under the heading "Areas Subject to Flooding" (see figure 4.40).

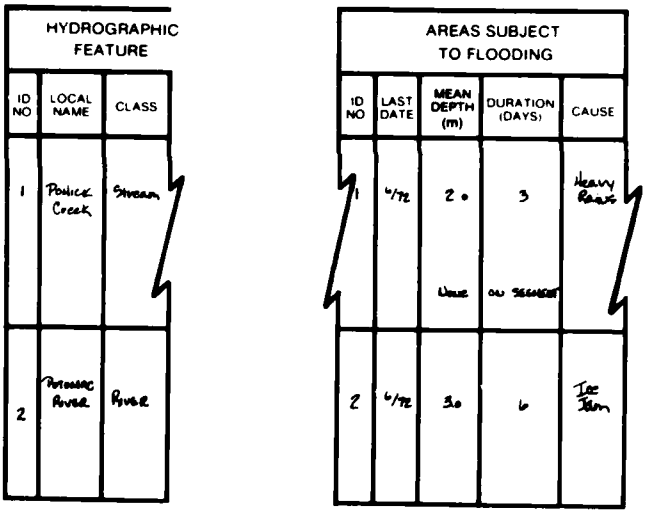


Figure 4.40 A Portion of Data Table 3 – Watercourses and Water Bodies.

*Areas subject to flooding can be determined from aerial photography only if the acquisition date of the photography coincides with the overflow period of the watercourse or water body. If these dates do not coincide, collateral information must be studied to provide the necessary information.

Step 6. When available, refer to local hydrology reports to obtain additional information on each flooded area.* Record this information as shown in figure 4.40.

4.2.2.11 Point and Area Obstacles

Step 1. Carefully compare the working overlay with the photo mosaic to determine if all point and area obstacles have been included on the overlay.

Step 2. Where discrepancies between overlay and mosaic exist, stereoscopically examine and identify the point or area obstacle of interest.

Step 3. Indicate the obstacle's location on the overlay with a hand-drafted symbol. For appropriate symbology, refer to the Coastal Hydrography section of DMAHTC TM S-1 or to appendix A2.

Step 4. Number each point and area obstacle consecutively, starting in the upper left corner of the overlay. Progress to the right and down the overlay in a normal reading manner (see figure 4.41).

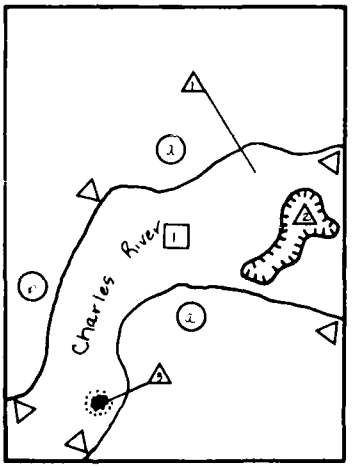


Figure 4.41 Working Overlay with Point and Area Obstacles Symbolized and Assigned ID Numbers.

*Data on historical floods in the U.S. have been published by the U.S. Geological Survey in a series of publications called "Hydrologic Investigations Atlases." These atlases shown areas flooded, stream gage data and other data.

Step 5. Record these ID numbers in Data Table 2 under the heading "Obstacles". Describe and sketch each to the fullest extent possible from the aerial photography (see figure 4.42).

HYDROGRAPHIC FEATURE			
ID NO	LOCAL NAME	CLASS	SEG NO
1	Charles River	River	a b a

OBSTACLES	
ID NO	DESCRIPTION/SKETCH
1	Wind Fall Trees
2	Shoal Area
3	Rocks Awash

Note: Data taken from Figure 4.41.

Figure 4.42 A Portion of Data Table 2 – Watercourses and Water Bodies.

4.2.2.12 Structures and Special Features/Areas

Step 1. For background information, review Hydrologic Structures and Special Features/Areas, section 4.2.1.6 and 4.2.1.7 respectively.

Step 2. Review stereograms 1 through 10 supplied with this guide as well as those portions of Engineer Intelligence Guide #32* related to the photo-identification of hydrologic structures and special features/areas.

Step 3. Carefully compare the working overlay with the photo mosaic to determine if all hydrologic structures and special features/areas have been included on the overlay.

Step 4. When discrepancies between the overlay and mosaic are discovered, stereoscopically examine and identify the structure, feature, or area of interest.

Step 5. Indicate the location of the structure, feature, or area on the overlay with a hand-drafted symbol. For appropriate symbology, refer to tables 1 and 2 as well as appendix A2.

Step 6. Number each hydrologic structure and special feature/area consecutively, starting in the upper left corner of the overlay. Progress to the right and down the overlay in a normal reading manner (see figure 4.43). If it is anticipated that the location of gaging stations can be determined from scientific literature, such as U.S.

*US Army Engineer Intelligence Guide, "Stream Hydrology and Hydraulic Structures," EIG 32.

Geological Survey Water-Data Reports, defer performing steps 5 through 7 until the gaging station locations have been recorded on the overlay.

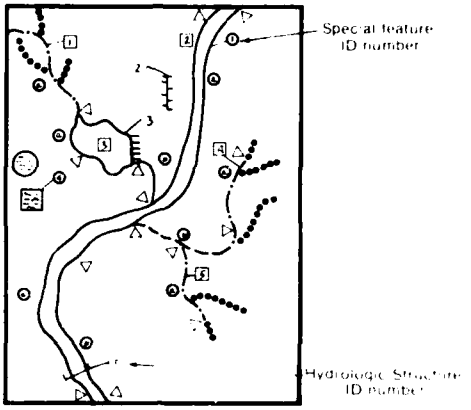
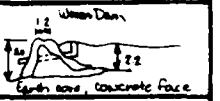


Figure 4.43 Working Overlay with Hydrologic Structures, Special Features, and Areas Assigned ID Numbers.

Step 7. Record these ID numbers in Data Table 3 under the heading "Structures and Special Features". Be sure to record each ID number in the appropriate row, i.e. opposite the hydrographic feature with which the structure or special feature/area is associated (see figure 4.44).

Step 8. Describe/sketch each structure or special feature/area to the fullest extent possible from the aerial photography. Supplement this with collateral information.

HYDROGRAPHIC FEATURE			
ID NO	LOCAL NAME	CLASS	SEG LETTER
1	Leaf Creek	Stream	a b
2	Goose River	River	a a b
3	Lake Wood	Lake	a
4	Myles River	River	a b
5	Watson Creek	Stream	a

STRUCTURES & SPECIAL FEATURES	
ID NO	DESCRIPTION SKETCH
	None
1	Numerous Small Boats Docks
2	Levee
4	Filtration Beds
5	Lock Lift 3 meters Max draft 2 meters
3	Watson Dam  Earth core, concrete face
	None
	None

Note: Data taken from Figure 4.43

Figure 4.44 A Portion of Data Table 3 – Watercourses and Water Bodies.

4.2.2.13 Factor Overlay and Data Table Completion Check

At this point in the analysis, information has been extracted primarily from topographic maps and aerial photography. Part of this information has been recorded on the overlay and part in the data tables.

Before proceeding with the literature analysis, compare the degree of completion of the working overlay and data tables with the information below. The degree of completion may vary somewhat from that below, depending upon whether the preceding topographic map and aerial photo analysis steps were followed in their entirety. Note those requirements that require completion, and attempt to fulfill them through literature analysis.

4.2.2.13.1 Completed Factor Overlay Requirements

1. Alinement of all watercourses.

2. Shore alinement of all water bodies.

3. Terminal points and identification of watercourses with dry gap widths of 3 m or greater.

4. Terminal points and identification of watercourse segments with dry gap widths of 3 m or greater.

5. Dry gap widths, by classes, of watercourses with gap widths of 3 m or greater.

6. Bank heights and min/max slopes above mean water for watercourses with gap widths greater than 50 m.

7. Delineation of wet areas.

8. Structures and Special Features/Areas.

9. Point and Area Obstacles.

10. Areas subject to flooding.

11. Location of fords and ferries.

12. Location of watercourse cross sections.

4.2.2.13.2 Factor Overlay Requirements to be Completed

1. Average maximum depth during seasonal high- and low-water periods.

2. Navigation channels.

4.2.2.13.3 Completed Data Table Requirements

1. Classification of watercourses, water bodies, and wet areas.

2. Dry gap widths

3. Bank heights and min/max slopes.

4. Description/sketch of point and area obstacles.

5. Areas subject to flooding.

6. Description/sketch of hydrologic structures and special features/areas.

7. Cross section sketches.

4.2.2.13.4 Data Table Requirements to be Completed

1. Seasonal depth, width, and velocity information.

2. Right and left bank material.

3. Maximum discharge.

4. Bottom conditions.

5. Tidal influence.

6. Water quality information.

7. Ice conditions.

8. Navigation information.

4.2.3 Literature Analysis

4.2.3.1 Background

The procedures to be followed when analyzing scientific information cannot be easily standardized because the analysis steps can vary greatly, depending upon the information source. In many cases, the available water resource information will be fragmentary or will not be in desired format for inclusion on the overlay or in the data tables. The

analyst must rely upon previous experience to extrapolate the data to reasonable limits or must reformat the data to satisfy the overlay and data table requirements.

Often, information used to prepare factor overlays or data tables will be taken from previously completed intelligence studies such as the National Intelligence Survey (NIS) documents. In these cases, the analyst will have no control over the type of data or its format. Again, the analyst's experience and judgment must be used to fulfill the overlay and data table requirements. In every situation, the analyst must compile the best and most complete information available within given time constraints and from this information, construct the best possible overlay and completed data tables.

4.2.3.2 Analysis

Step 1. The first step of the literature analysis is to assemble water resource information. To do this, locate a water resource information expert for the country of interest. The experts may be located in U.S. Government agencies such as the Defense Intelligence Agency (DIA), the Central Intelligence Agency (CIA), the US Geological Survey (USGS), or the Bureau of Reclamation. Next, review appendix B and contact these sources, as necessary, for specific information. Then analyze the information and extract data, as required, to complete the overlay and data tables. For USGS Water Resources Data Reports, follow these steps of a sample extraction method:

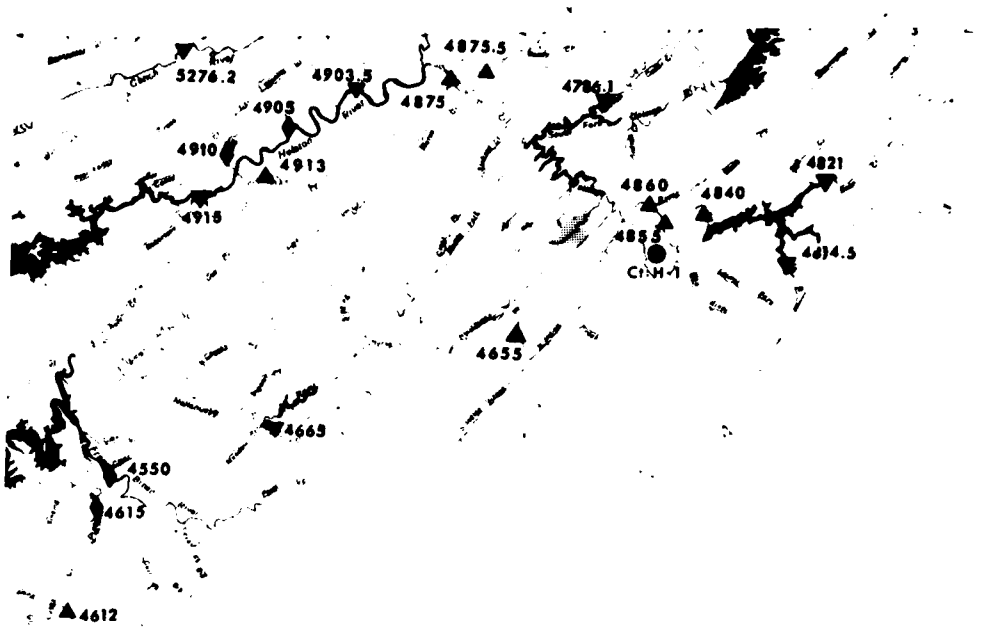
Step 2. Obtain the most recent USGS Water Resources Data Report or similar document for the area of interest. When available, also obtain water resource documents for those years immediately preceding the most recent one.

Step 3. Generally, a map will be provided with the document that shows the location of all gaging stations covered by the report (see figure 4.45). Study this map and determine which stations fall within the limits of the 1:50,000 scale topographic map.

Step 4. Locate within the body of the report the streamflow gaging site(s) of interest. Use the streamflow data and related information to fill information gaps in the data tables. The following example is given to illustrate the type of information that can be extracted from typical stream-gaging-station data.

Step 5. Determine the months of high- and low-water conditions.

a. Use the location information, like that shown at the top of figure 4.46, to locate the gaging station on the working overlay. Remember that gaging stations are included under Special Features and must be symbolized and numbered as such.



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF TENNESSEE

10 0 10 20 30 40 Miles

Scale

EXPLANATION

- ● Pm:C-1 Active observation wells
- ▲ 4350 Streamflow gaging station
- ▼ 4661 Water-quality sampling station
- ♦ 6040 Both streamflow gaging and water-quality sampling station
- Part 2 Eastern Gulf of Mexico basin
- Part 3 Ohio River basin
- Part 7 Lower Mississippi River basin
- ——— Drainage divide

Figure 4.45 Location of Data Collection Stations.

TENNESSEE RIVER BASIN

03599500 Duck River at Columbia, Tenn.

LOCATION.--Lat 35°37'05", long 87°01'56", Maury County, on right bank 4 ft (1 m) downstream from bridge on former U.S. Highway 31, 2 blocks north of public square at Columbia, 0.7 mile (1.1 km) downstream from Columbia hydroelectric plant, 2.4 miles (3.9 km) upstream from Rutherford Creek, and at mile 132.8 (213.7 km).

DRAINAGE AREA.--1,208 sq mi (3,129 sq km).

PERIOD OF RECORD.--October 1904 to December 1908, April 1920 to current year. Monthly discharge only for some periods, published in WSP 1306. Gage-height records collected at same site, 1887-95 and 1911 (fragmentary), and since 1947, are in reports of U.S. Weather Bureau.

GAGE.--Water-stage recorder. Datum of gage is 535.31 ft (161.169 m) above mean sea level. Prior to Jan. 9, 1925, nonrecording gages near this site; all gages at datum 2.37 ft (0.722 m) higher prior to Oct. 1, 1933.

AVERAGE DISCHARGE.--59 years, 1904-8, 1920-75, 1,993 cfs (56.44 cu m/s), 22.40 in/yr (569 mm/yr).

EXTREMES.--Current year: Maximum discharge, 58,400 cfs (1,650 cu m/s) Mar. 14, gage height, 48.31 ft (14.725 m); minimum, 94 cfs (2.66 cu m/s) Sept. 1.
Period of record: Maximum discharge, 61,500 cfs (1,740 cu m/s) Mar. 17, 1973; maximum gage height, 51.75 ft (15.773 m) Feb. 14, 1948, no flow Oct. 22, 1922.
Flood of Mar. 30, 1902, reached a stage of 48.0 ft (14.63 m), present datum, discharge, 50,700 cfs (1,440 cu m/s).

REMARKS.--Records good. Records of periodic water temperatures for the current year are published in Part 2 of this report.

REVISIONS (WATER YEARS).--WSP 783: 1929(M). WSP 853: Drainage area. WSP 1306: 1905-9, 1920-22, 1923(M).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	257	151	1,200	5,640	1,410	1,550	12,300	807	923	262	144	105
2	254	150	1,950	4,810	3,510	1,420	8,810	754	750	245	138	99
3	238	150	2,120	4,020	5,740	1,370	4,480	733	542	786	140	95
4	206	187	1,860	3,540	10,700	1,260	3,340	717	501	480	357	98
5	185	457	1,540	3,600	14,600	1,150	2,630	680	436	329	654	99
6	168	516	1,320	3,180	11,400	1,040	2,140	645	392	269	340	103
7	158	514	1,710	2,580	7,460	1,030	1,810	2,120	365	247	268	116
8	151	427	3,080	2,400	5,000	1,380	1,580	5,890	327	260	214	105
9	146	339	3,840	4,110	3,710	1,280	1,440	5,040	306	229	217	108
10	141	262	3,170	13,600	2,940	1,330	1,330	4,870	300	210	228	115
11	134	386	2,390	24,600	2,470	1,880	1,230	2,860	310	247	221	135
12	136	884	1,830	21,400	5,200	12,400	1,110	1,940	337	346	228	158
13	134	734	1,500	11,400	4,130	46,700	1,000	1,430	1,410	276	221	525
14	132	649	1,270	5,720	3,150	57,400	952	1,140	1,530	206	179	338
15	148	563	1,130	4,070	2,540	54,700	967	2,690	909	178	224	225
16	234	485	1,260	3,360	2,350	46,800	1,080	7,220	2,710	169	214	183
17	338	484	1,220	3,040	4,230	28,900	961	7,170	1,590	202	210	159
18	413	3,260	1,080	2,780	5,550	8,750	863	4,490	911	183	207	143
19	421	7,740	949	4,250	5,530	4,700	1,180	3,290	767	218	522	131
20	342	12,200	866	7,890	4,420	4,230	2,920	2,320	1,830	605	701	211
21	280	10,100	798	7,680	3,340	3,660	3,090	1,730	2,080	2,340	479	407
22	215	5,180	737	5,820	2,840	3,630	2,220	1,360	914	622	354	354
23	190	3,120	685	3,940	2,610	4,370	1,550	1,110	672	390	248	1,230
24	177	2,090	2,230	3,080	3,440	6,510	1,240	920	539	299	188	5,340
25	170	1,940	17,900	2,840	3,460	12,100	1,170	809	466	240	155	8,080
26	165	1,700	22,700	2,530	2,600	9,710	1,370	714	379	541	135	4,540
27	160	1,390	19,800	2,410	2,100	5,370	1,330	649	371	317	121	2,880
28	156	1,150	16,900	2,130	1,770	3,400	1,140	580	366	234	112	1,760
29	156	970	16,400	1,780	------	8,100	976	550	346	200	107	1,190
30	156	885	13,100	1,580	------	19,100	867	570	295	174	108	917
31	155	------	8,320	1,470	------	19,400	------	699	------	155	111	------
TOTAL	6,301	54,083	154,675	170,830	128,000	373,620	64,876	66,502	23,629	11,609	7,795	29,949
MEAN	203	1,969	4,990	5,511	4,571	12,050	2,163	2,145	788	374	251	998
MAX	421	12,200	22,700	24,600	14,600	57,400	12,300	7,220	2,710	2,340	701	8,080
MIN	132	150	685	1,470	1,410	1,030	863	550	295	155	107	95
CFSM	.17	1.63	4.13	4.56	3.78	9.98	1.79	1.78	.65	.31	.21	.83
IN.	.19	1.82	4.76	5.26	3.94	11.51	2.00	2.05	.73	.36	.24	.92

CAL YR 1974 TOTAL 1,070,650 MEAN 2,933 MAX 39,800 MIN 132 CFSM 2.43 IN 32.97
WTR YR 1975 TOTAL 1,096,869 MEAN 3,005 MAX 57,400 MIN 95 CFSM 2.49 IN 33.78

PEAK DISCHARGE (BASE, 16,000 CFS)

DATE	TIME	G.HT.	DISCHARGE	DATE	TIME	G.HT.	DISCHARGE
12-26	1600	31.82	21,200	03-14	0600	48.31	58,400
01-11	0500	33.15	24,800	03-31	0200	29.35	20,600

Figure 4.46 Stream Gage Data.

b. Determine the month(s) of high-water conditions by examining the total months discharge record. For the example shown, March has the highest total discharge value (373,620). Record the abbreviation for the month of March in Data Table 1. Watercourse and Water Bodies (see appendix A2, figure A4). Remember to record this information opposite the watercourse segment that the gaging station is located on. (More than one month may be recorded as the period of high-water conditions only if additional annual discharge records are available that indicate this to be true.)

Step 6. Examine the narrative portion of the stream gage data and locate the maximum discharge for the period of record. Record this value in cubic meters per second (cu m/s) in the appropriate column of Data Table 1. If the discharge value is given in cubic feet per second (cfs) convert this value to cu m/s by multiplying by a conversion factor, for example, 61,500 cfs x 0.02831 = 1741 cu m/s.

Step 7. Determine the mean minimum and maximum water depths during high- and low-water conditions.

a. Locate within the given data the mean discharge values for the months of high- and low-water conditions. (For example shown, the mean high- and low-water discharge values are 12,050 and 203 cfs, respectively.)

b. Use the procedure in Paragraph 21, Engineer Intelligence Guide #32 entitled "Special techniques for estimating discharge, depth, and velocity" to calculate minimum and maximum water depths for both high- and low-water conditions.

c. Record these values in the appropriate columns of Data Table 1. The calculated depth values should be used with caution and whenever possible, should be checked for accuracy by comparing these values with depth values recorded elsewhere in the literature.

Step 8. Record the location of all water-quality sampling sites on the working overlay.

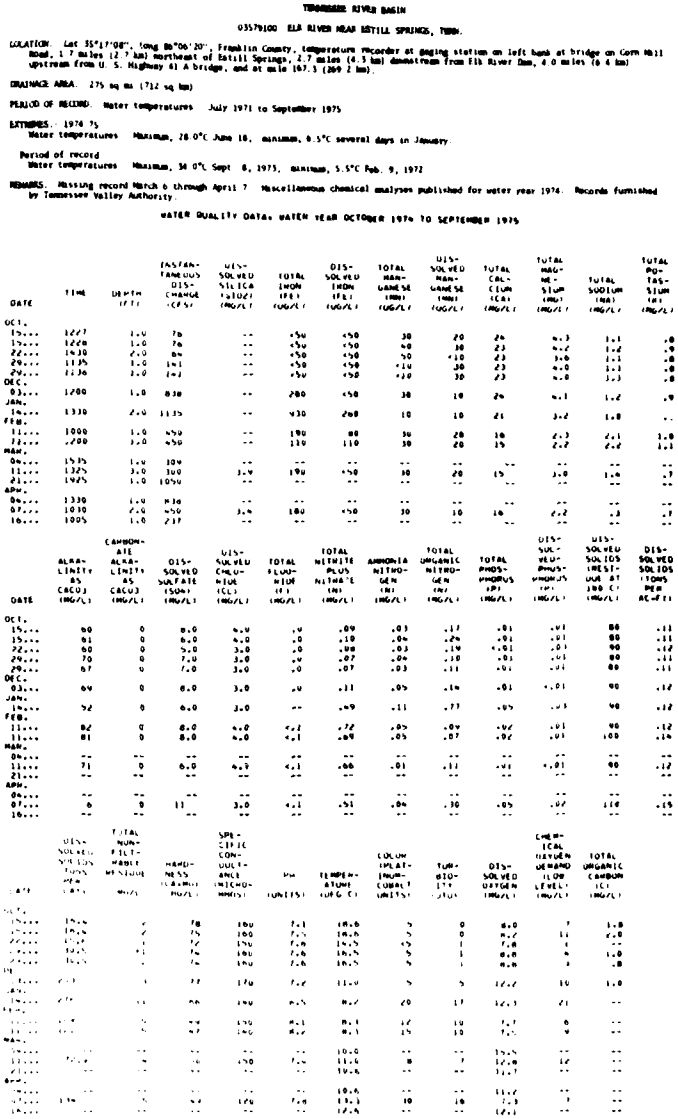
a. If provided, study the map showing the location of water-quality sampling sites. Determine those sites that fall within the limits of the 1:50,000 scale topographic map.

b. On the working overlay, symbolize each site as described in appendix A2. Assign an ID number to each site. Start in the upper left corner of the overlay and work across and down the overlay in a normal reading manner.

Step 9. Transcribe the water-quality information to Data Table 2. Watercourses and Water Bodies (see appendix A2, figure A5).

a. Record the ID number for each site in Data Table 2 opposite the watercourse segment that the sampling site is located on.

b. Locate within the body of the report each site's water-quality information (figure 4.47). Transcribe the water-quality parameters* to Data Table 2.



TENNESSEE RIVER BASIN

03579100 ELK RIVER NEAR ESTILL SPRINGS, TENN.

LOCATION.--Lat 35°17'08", long 86°06'20", Franklin County, temperature recorder at gaging station on left bank at bridge on Corn Mill Road, 1.7 miles (2.7 km) northeast of Estill Springs, 2.7 miles (4.3 km) downstream from Elk River Dam, 4.0 miles (6.4 km) upstream from U. S. Highway 41 A bridge, and at mile 167.3 (269.2 km).

DRAINAGE AREA.--275 sq mi (712 sq km)

PERIOD OF RECORD.--Water temperatures: July 1971 to September 1975

EXTREMES.--1974-75
Water temperatures: Maximum, 28.0°C June 18, minimum, 0.5°C several days in January.

Period of record
Water temperatures: Maximum, 34.0°C Sept. 6, 1975, minimum, 5.5°C Feb. 9, 1972

REMARKS.--Missing record March 6 through April 7. Miscellaneous chemical analyses published for water year 1974. Records furnished by Tennessee Valley Authority.

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DEPTH (FT)	EASTER-LY DIS-CHARGE (CFS)	DIS-SOLVED SILICA (SiO2) (MG/L)	TOTAL IRON (Fe) (UG/L)	DIS-SOLVED IRON (Fe) (UG/L)	TOTAL MAN-GANESE (Mn) (UG/L)	DIS-SOLVED MAN-GANESE (Mn) (UG/L)	TOTAL CAL-CIUM (Ca) (MG/L)	TOTAL MAG-NE-SIUM (Mg) (MG/L)	TOTAL SODIUM (Na) (MG/L)	TOTAL PO-TAS-SIUM (K) (MG/L)
OCT.												
15...	1227	1.0	78	--	<50	<50	30	20	24	4.3	3.1	.8
17...	1240	1.0	76	--	<50	<50	40	30	23	4.2	3.2	.9
22...	1430	2.0	84	--	<50	<50	50	<10	23	3.9	3.1	.8
29...	1135	1.0	141	--	<50	<50	<10	30	23	4.0	3.3	.8
29...	1230	1.0	141	--	<50	<50	<10	30	23	4.0	3.3	.8
DEC.												
03...	1200	1.0	838	--	280	<50	30	10	24	4.1	3.2	.9
JAN.												
14...	1330	2.0	1135	--	430	260	10	10	21	3.2	3.0	..
FEB.												
11...	1000	1.0	459	--	190	80	30	20	18	2.3	2.1	1.0
12...	1200	1.0	450	--	110	110	30	20	15	2.2	2.2	1.1
MAR.												
04...	1535	1.0	304	--	--	--	--	--	--	--	--	--
11...	1325	1.0	300	3.9	190	<50	30	20	15	3.0	1.6	.7
21...	1025	1.0	1050	--	--	--	--	--	--	--	--	--
APR.												
04...	1330	1.0	436	--	--	--	--	--	--	--	--	--
07...	1030	2.0	450	3.6	180	<50	30	10	16	2.2	1.8	.7
16...	1005	1.0	237	--	--	--	--	--	--	--	--	--

DATE	ALKA-LINITY AS CaCO3 (MG/L)	CARBON-ATE ALKA-LINITY AS CaCO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (Cl) (MG/L)	TOTAL FLUO-RIDE (F) (MG/L)	TOTAL NITRITE PLUS NITRATE (N) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	TOTAL ORGANIC NITRO-GEN (N) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	DIS-SOL-VED PHOS-PHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (RESI-DUE AT 180 C) (MG/L)	DIS-SOLVED SOLIDS (TONS PER AC-FT)
OCT.												
15...	60	0	8.0	4.0	.0	.09	.03	.17	.01	.01	88	.11
15...	61	0	8.0	4.0	.0	.10	.04	<.24	.01	.01	88	.11
22...	60	0	5.0	3.0	.0	.08	.03	.19	<.01	.01	90	.12
29...	70	0	7.0	3.0	.0	.07	.04	.10	.01	.01	80	.11
29...	67	0	7.0	3.0	.0	.07	.03	.11	.01	.01	80	.11
DEC.												
03...	69	0	8.0	3.0	.0	.11	.05	.14	.01	<.01	90	.12
JAN.												
14...	92	0	6.0	3.0	--	.49	.11	.77	.05	.03	98	.13
FEB.												
11...	82	0	8.0	4.0	<.2	.72	.05	.09	.02	.01	98	.13
12...	81	0	8.0	4.0	<.1	.69	.05	.07	.02	.01	100	.14
MAR.												
04...	--	--	--	--	--	--	--	--	--	--	--	--
11...	71	0	6.0	4.0	<.1	.66	.01	.11	<.01	<.01	90	.12
21...	--	--	--	--	--	--	--	--	--	--	--	--
APR.												
04...	--	--	--	--	--	--	--	--	--	--	--	--
07...	6	0	11	3.0	<.1	.51	.04	.30	.05	.02	110	.15
16...	--	--	--	--	--	--	--	--	--	--	--	--

DATE	DIS-SOLVED SOLIDS (TONS PER DAY)	TOTAL NON-FILT-RABLE RESIDUE (MG/L)	HARD-NESS (CaMg) (MG/L)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	pH (UNITS)	TEMPER-ATURE (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	CHEM-ICAL (OXYGEN DEMAND) HIGH LEVEL (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
OCT.											
15...	[illegible]	7	78	180	7.1	18.0	5	0	8.0	7	3.0
17...	[illegible]	7	72	180	7.5	16.0	5	0	8.2	11	2.0
22...	[illegible]	7	72	170	7.8	14.5	<5	1	7.8	6	--
29...	[illegible]	11	74	180	7.8	10.5	5	1	8.8	9	1.0
29...	[illegible]	1	74	180	7.8	10.5	5	1	8.8	3	.8
DEC.											
03...	[illegible]	1	77	170	7.2	11.0	5	5	12.2	10	1.0
JAN.											
14...	[illegible]	11	88	190	8.5	8.2	20	17	12.3	21	--
FEB.											
11...	[illegible]	0	93	170	8.1	8.1	12	10	11.7	8	--
12...	[illegible]	5	97	190	8.2	8.1	15	10	11.5	9	--
MAR.											
04...	[illegible]	--	--	--	--	10.0	--	--	10.5	--	--
11...	[illegible]	5	76	170	7.4	11.5	10	7	12.0	12	--
21...	[illegible]	--	--	--	--	10.5	--	--	11.1	--	--
APR.											
04...	[illegible]	--	--	--	--	10.5	--	--	11.2	--	--
07...	[illegible]	5	94	190	7.8	13.1	10	10	11.3	7	--
16...	[illegible]	--	--	--	--	12.5	--	--	12.1	--	--

Figure 4.47 Water Quality Data.

*For the purposes of this guide, milligrams per liter (mg/l) may be taken to be equivalent to parts per million (ppm).

4.3 Drainage Basins

The following paragraphs provide the steps necessary to complete the requirements for preparing the drainage basin overlay and supporting data tables using: 4.3.1 Topographic Map Analysis, 4.3.2 Photo Analysis, and 4.3.3 Literature Analysis. The procedures referred to under Topographic Map, Photo, and Literature Analyses are in section 4.5, "Supplementary Procedures".

Normally, the majority of the information required to complete the drainage basin factor overlay and data tables can be obtained by topographic map analysis. However, exceptions can occur, such as when flood control projects are initiated after the map publication date. In this and similar situations, aerial photography acquired over all or portions of the study area must be analyzed. In all cases, scientific literature should be used to supplement the map and photo analysis.

4.3.1 Topographic Map Analysis

4.3.1.1 Delineate drainage basin boundaries

Step 1. Review the indexes to the data base and withdraw source materials pertinent to hydrology, drainage, and water resources. These materials should include 1:1,000,000, 1:250,000, and 1:50,000 scale maps as well as aerial photography and special studies on the area of interest. In addition, it will be useful to obtain each of the four 1:50,000 map sheets adjacent to the one being analyzed.

Step 2. Review the materials obtained in step 1 and determine if they appear adequate to generate the factor overlay and data tables. If they provide insufficient detail or area coverage, initiate collection efforts to obtain additional information. Start the analysis with the materials on hand.

Step 3. Use Procedure 1 (4.5.1) to register the overlay material to the 1:50,000 topographic map.

Step 4. Use Procedure 2 (4.5.2) to prepare the data tables.

Step 5. Place the map and registered overlay material on a light table, and trace the alinement of all watercourses and water body shorelines*. Watercourses with gap widths of 50 m or less are symbolized

*Check to see if the watercourses and water bodies factor overlay has been completed. If it has been completed, use it rather than the map sheet for watercourse alinement.

with a single solid line. Watercourses with gap widths greater than 50 m and all water body shorelines are drawn to scale.

Step 6. Delineate the boundaries of each primary, secondary, and tertiary drainage basin present on the map sheet.

a. The classification method used to identify primary, secondary, and tertiary drainage basins is based upon the relative size of watercourses within the 1:50,000 map sheet, i.e. largest watercourse(s) form primary drainage basins and smallest watercourses form tertiary drainage basins. An important point to remember when applying this method is that it is not as important whether a given watercourse is classified as primary, secondary, or tertiary, but rather that a consistent system is used to identify each drainage basin on the overlay.

b. Study the watercourse drainage network and note on the overlay which watercourses form primary, secondary and tertiary drainage basins. Refer to figure 4.48 and to the following information:

1. Primary watercourses can be identified by various characteristics that although accurate in general, may not always hold for a particular map sheet. In general, primary watercourses are the largest watercourses on the map sheet, are the collection channels for large portions of the sheet, and have the longest drainage channels on the sheet.

2. Secondary watercourses can be identified by the fact that they drain into primary watercourses.

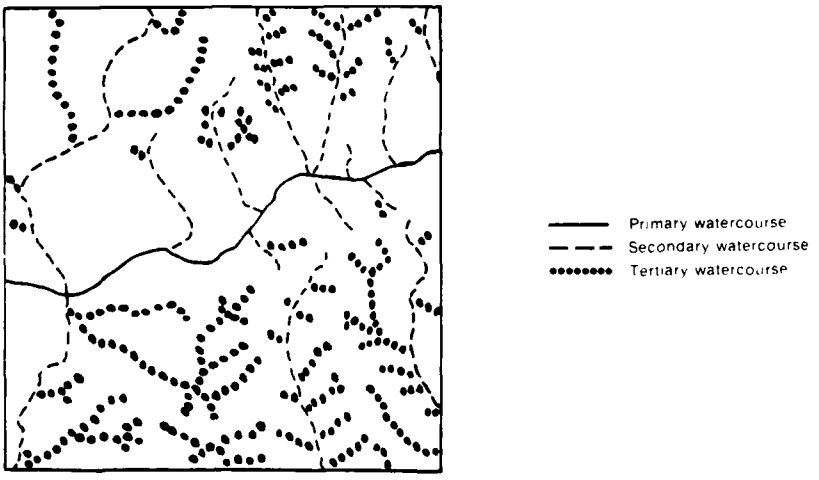


Figure 4.48 Drainage Network with Primary, Secondary, and Tertiary Watercourses Identified.

3. Tertiary watercourses can be identified by the fact that they drain into secondary watercourses or other tertiary watercourses.

c. Use the notes compiled in the preceding paragraphs, along with elevation information on the topographic map, to outline primary, secondary, and tertiary drainage basins.

Remember a drainage basin is that area of the terrain from which a watercourse or network of watercourses receives precipitation. The drainage divides or basin boundaries delineated on a map sheet are the topographic location where precipitation falling on one side of the divide will flow to one watercourse or network of watercourses, while precipitation falling on the other side of the divide will flow to another watercourse or network of watercourses. In figure 4.49, a basin divide boundary line is placed between watercourses A and B.

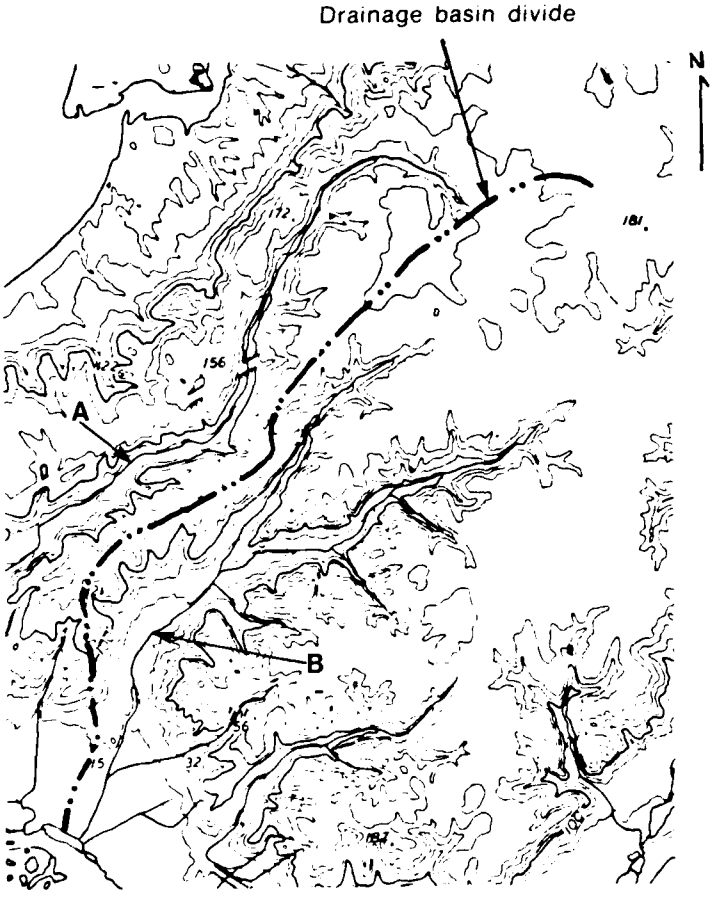


Figure 4.49 Drainage Basin Divide Shown Between Watercourses A and B.

Precipitation in the illustrated area will be divided into two portions. Northwest of the boundary line, runoff from precipitation will flow into watercourse A, and precipitation falling southeast of the line will enter watercourse B. Delineation of the entire drainage basin for watercourse B is illustrated in figure 4.50. This was achieved by studying the contour lines and then by marking the divide between slopes that drain toward watercourse B from those that drain away from watercourse B.

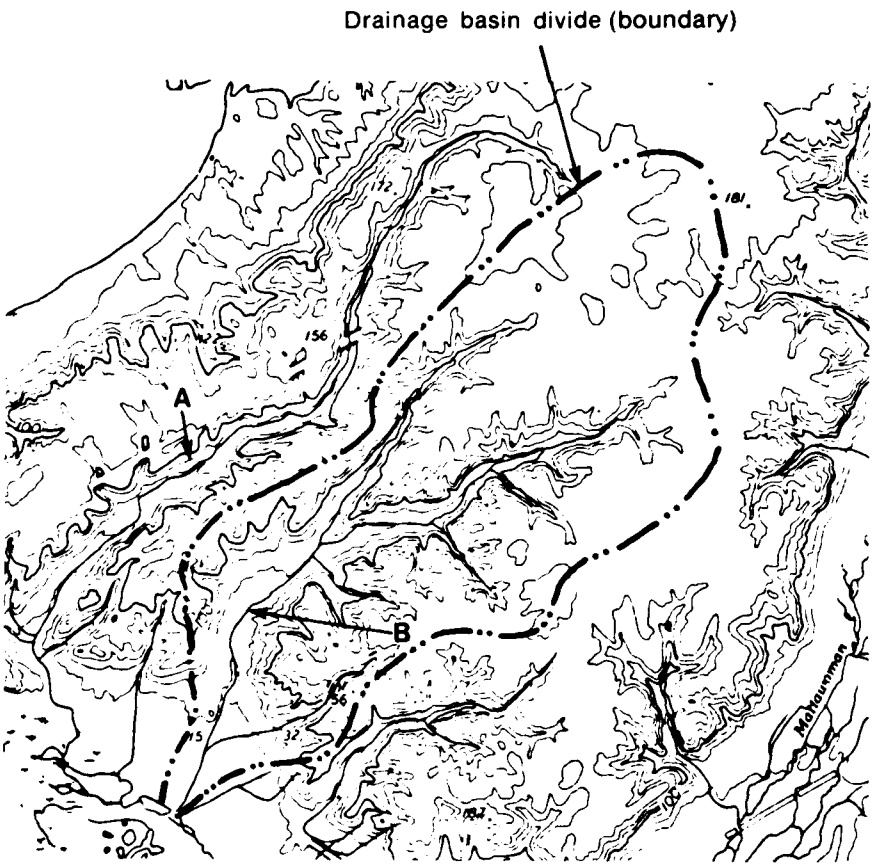
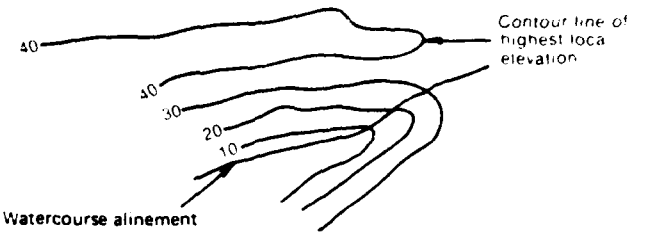
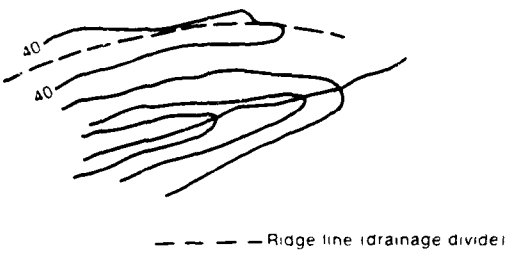


Figure 4.50 Drainage Basin Boundary for Watercourse B.

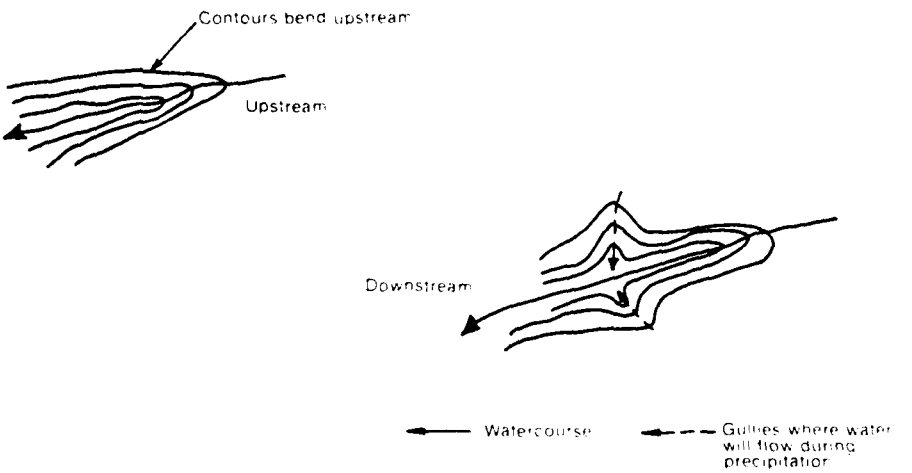
1. Begin your analysis at the watercourse. Locate the nearest contour line of highest local elevation that basically parallels the alinement of the watercourse (see following example).



In the example below, the ridge line (drainage divide) can be estimated to lie halfway between the 40 foot contour lines as shown below.



Remember that contour lines bend in the upstream direction when they cross watercourse channels or gullies.



Use this information to define the location of ridge lines (drainage divides) in areas of complicated topography.

2. Study the remaining basin topography as depicted by the contour lines and estimate the location of basin boundaries.

3. Extend your drainage divide analysis to adjacent basins. Upon completion of the analysis, all primary, secondary, and tertiary drainage basins shown on the map should be outlined.

4. If continuous lines were initially used for basin boundaries, replace these lines with the appropriate boundary line symbolization (see appendix A3).

4.3.1.2 Assign identification nomenclature to each outlined drainage basin

Step 1. Assign a single letter identifier, e.g. A, B, C, sequentially to each primary drainage basin on the overlay. Start this identification process in the upper left corner of the overlay and proceed across and down in a normal reading manner.

Step 2. Assign each secondary drainage basin a double letter identifier, e.g. AA, AB, AC. Refer to figure 4.51 and note the way in which these identifiers were assigned. Also consult adjacent 1:50,000 topographic map sheets to aid in assigning identifiers to watercourses that run off the map sheet. The analyst's approach to assigning basin identifiers may differ somewhat from that shown in figure 4.51. The important point to remember is that the identifiers should be assigned consistently throughout the map sheet.

Step 3. Assign an alphanumeric identifier, e.g. AB1, AB2, AB3, to each tertiary drainage basin on the overlay. Note that each tertiary basin identifier contains a primary basin letter, A; a secondary basin letter, B; and a tertiary basin number, e.g., 1, 2, 3. Again refer to figure 4.51 which shows how to assign basin identifiers.

Step 4. Record the basin identifiers in column 1 of the appropriate data table.

4.3.1.3 Complete the data requirements for Data Table 4. Primary Drainage Basins*

Step 1. For each primary basin outlined on the topographic map, locate the name of the watercourse that forms the basin. Record this name in column 2.

Step 2. Use the topographic map to determine the major political units, e.g. borough, township, county, that have jurisdiction in the basin. Record these units in column 3.

*See appendix A3, figure A8. Format for Drainage Basin Data Tables.

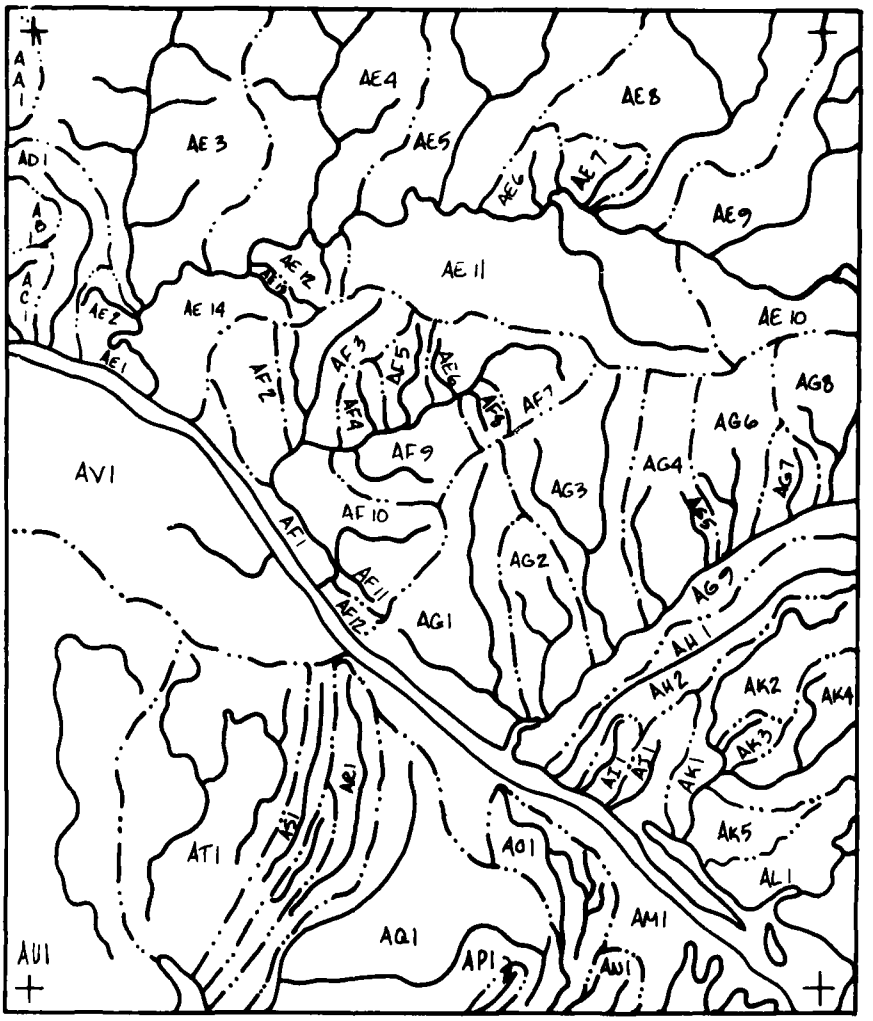


Figure 4.51 Factor Overlay with Identification Nomenclature Assigned to Each Drainage Basin.

Step 3. Determine the area of each primary basin.* There are several types of equipment that can be used to determine surface area such as electronic planimeters, polar planimeters, and area grids. The area grid method requires the least sophisticated equipment and is outlined below. When a planimeter is available, follow instructions provided with the instrument.

a. Secure the area grid** over the drainage basin with tape. (The accuracy of this method can be maximized by using the finest mesh grid that is compatible with the area of the basin.)

b. Count the number of full squares that fall within the boundaries of the basin (see the example in figure 4.52). In the example, the number of full squares is 30.

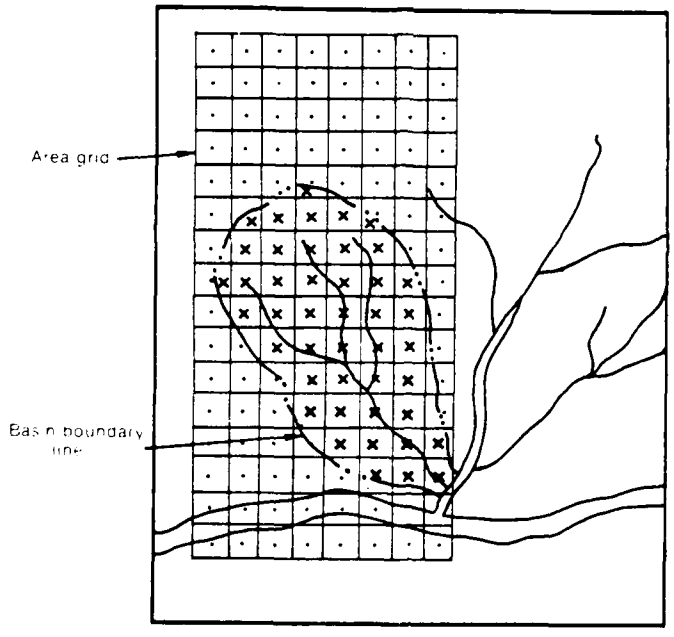


Figure 4.52 Placement of Grid for Calculation of Basin Area.

*This procedure can also be applied to secondary and tertiary drainage basins.

**This grid may be constructed from a stable base transparent material on which a checkerboard pattern of squares of equal size is drawn.

e. Estimate the proportion of each partial square that falls inside the basin's boundary line, e.g. 3/10, 1/2. Add these partial squares together. In the example the number of boundary squares is 14.4.

d. Add together the number of full and partial squares. The total number of squares in basin is 30 + 14.4 = 40.4.

e. Determine the number of square inches that the total in step d represents. Divide the total number of squares by the number of grid squares/per square inch. In the example, 16 grid squares equals 1 square inch.

$$\frac{\text{Total no. of squares}}{\text{No. of grid squares/sq. in.}} = \frac{40.4}{16} = 2.53 \text{ in}^2$$

f. Determine the ground area (hectares) that the map area determined in step e represents:

1 sq. in. (map area) = 161.3 hectares (ground area for 1:50,000 scale map)

Basin Ground Area = 2.53 x 161.3 hectares
= 408.09 hectares

g. Round off the ground area value to the nearest tenth hectare and record it in column 4.

Step 4. Use the following steps to determine primary drainage channel length.*

a. To facilitate measurement, mark off portions of the watercourse that are approximately straight. Straight portions of the watercourse shown in figure 4.53 correspond to segments labeled A through F.

b. Beginning with the furthest upstream segment, mark off the length on a scrap piece of paper. Methodically advance the paper downstream. With each advance, add the adjacent straight line segment distance to that previously recorded on the paper. After progressing the full length of the watercourse, the total channel length should be recorded on the paper.

c. To determine the actual length of the channel, compare the channel length, as recorded on the paper, with the

*This procedure can also be applied to secondary and tertiary watercourses.

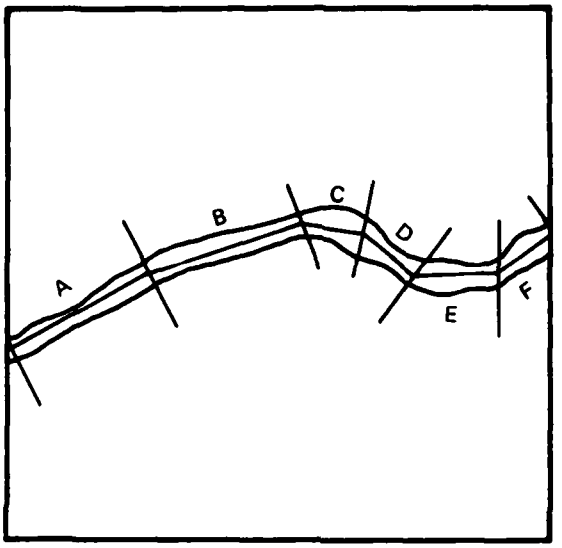


Figure 4.53 Watercourse with Straight Segments Delineated.

meter scale at the bottom of the map sheet (see figure 4.54). For the example shown, the channel length is approximately 4,450 meters.

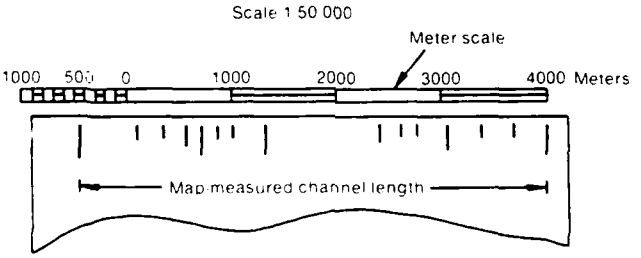


Figure 4.54 Comparison of the Map-Measured Channel Length and Meter Scale.

d. Convert the channel length in meters to kilometers:

$$1000 \text{ m} = 1 \text{ km}$$

$$\frac{4{,}450 \text{ m}}{1} \times \frac{1 \text{ km}}{1000 \text{ m}} = 4.45 \text{ km}$$

e. Round off the channel length value to the nearest tenth km and record it in column 5 of Data Table 4.

Step 5. Determine the type and location of hydrologic structures.*

a. Review Table 2. Overlay Representations of Miscellaneous Features. This table contains the map symbols for many types of hydrologic structures, which if present on the map sheet, should be included in the data table.

b. Study each primary drainage basin and determine the type of each hydrologic structure present in the basin. Record the type, e.g. dam, levee, lock, in column 6.

c. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each structure. Record the coordinates in column 7.

Step 6. Determine the number of secondary and tertiary basins in each primary basin. Record the number of secondary basins in column 8 and the number of tertiary basins in column 9.

4.3.1.4 Complete the data requirements for Data Table 5. Secondary Drainage Basins.**

Step 1. For each secondary basin outlined on the topographic map, locate the name of the watercourse that forms the basin. Record this name in column 2. If no name is given, write "unnamed" in the column.

Step 2. Determine the area of each secondary basin.

a. Use step 3 located in paragraph 4.3.1.3 to determine the area of each secondary basin.

b. Record the basin area value to the nearest tenth hectare in column 3.

Step 3. Determine the channel length of each secondary watercourse.

a. Before measuring the channel length of each secondary watercourse, the analyst must extend the upstream portion of each channel to its respective basin boundary line. To do this, study the contour lines within each basin and thereby determine the most probable watercourse alinement to the boundary line.

---

*Check to see if the watercourses and water bodies overlay has been completed. If it has, use it to locate the hydrologic structures.

**See appendix A3, figure A8. Format for Drainage Basin Tables.

b. Use step 4 located in paragraph 4.3.1.3 to measure the channel length. This is the distance measured from the point where the secondary watercourse enters the primary watercourse to the point where the extended watercourse intersects the basin boundary line (see figure 4.55). If the entire watercourse is not shown on the map, measure the distance from the point where the watercourse enters the primary watercourse to the point where it crosses the map neatline.

c. Round off the calculated value to the nearest tenth km and record it in column 4 of Data Table 5.

Step 4. Determine the type and location of hydrologic structures not recorded previously in Data Table 4.*

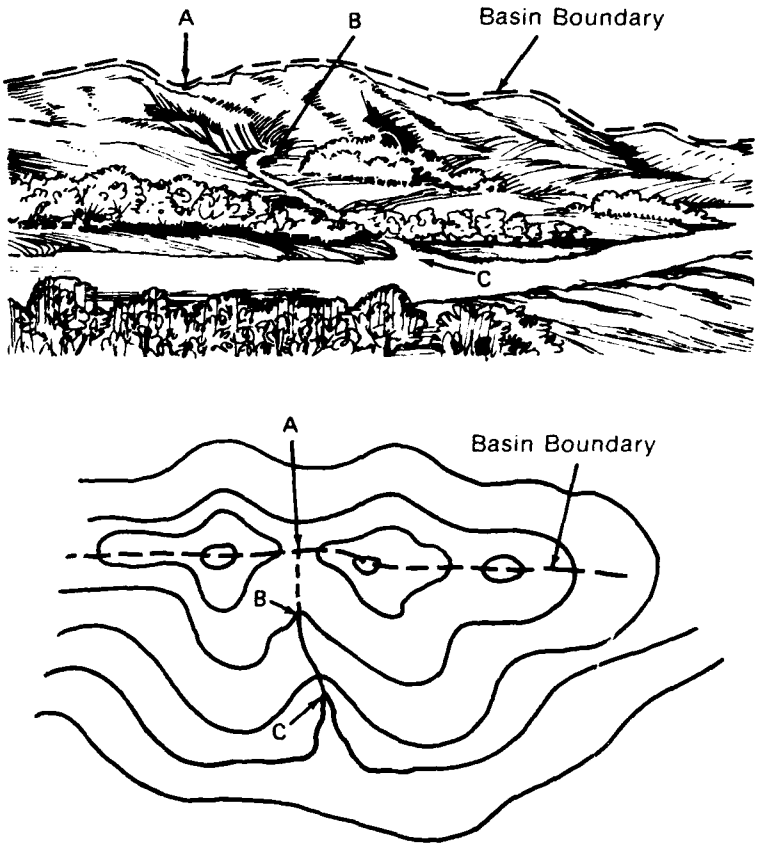


Figure 4.55 Oblique and Plan Views of Same Area with AB = Distance the Watercourse was extended; AC = Length of Watercourse Channel.

*This procedure should be followed only if the secondary basin of interest is not part of one of the primary basins outlined on the map sheet.

a. Review Table 2. Overlay Representations of Miscellaneous Features. This table contains the map symbols for many types of hydrologic structures, which if present on the map sheet, should be included in the data table.

b. Study each secondary basin and determine the type of each hydrologic structure present in the basin. Record the type, e.g. dam, levee, lock, in column 5.

c. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each structure. Record the coordinates in column 6.

4.3.1.5 Complete the data requirements for Data Table 6. Tertiary Drainage Basins.*

Step 1. For each tertiary basin outlined on the topographic map, locate the name of the watercourse that forms the basin. Record this name in column 2. If more than one watercourse is present in the basin, record the name of the one that drains the largest portion of the basin. If no name is given, write "unnamed" in the column.

Step 2. Determine the area of each tertiary basin.

a. Use step 3 located in paragraph 4.3.1.3 to determine the area of each teritary basin.

b. Record the calculated basin area to the nearest tenth hectare in column 3.

Step 3. Determine the channel length of the main watercourse in each tertiary drainage basin.

a. Identify the watercourse in each basin that drains the largest portion of the basin. This is the main watercourse and the one whose channel length should be measured.

b. As required, extend the upstream portion of each main watercourse to its respective basin boundary line. To do this, study the contour lines within each basin and thereby determine the most probable watercourse alignment to the boundary line.

c. Use step 4 located in paragraph 4.3.1.3 to measure the channel length. This is the distance measured from the point where the extended watercourse intersects the basin boundary line. If the entire watercourse is not shown on the map, measure the distance from the point where the watercourse enters the secondary watercourse to the point where it crosses the map neatline.

*See appendix A3, figure A8. Format for Drainage Basin Data Tables.

Step 4. Determine the type and location of hydrologic structures not recorded previously in Data Tables 4 or 5.*

a. Review Table 2. Overlay Representations of Miscellaneous Features. This table contains the map symbols for many types of hydrologic structures which, if present on the map sheet, should be included in the data table.

b. Study each tertiary basin and determine the type of each hydrologic structure present in the basin. Record the type, e.g. dam, lock, levee, in column 5. If there are no hydrologic structures in the basin, write "none" in the column.

c. Use Procedure 4 (4.5.4) to determine the UTM coordinates. Record the coordinates in column 6.

4.3.2 Photo Analysis

4.3.2.1 Delineate drainage basin boundaries

Step 1. Use Procedure 3 (4.5.3) to prepare a photo mosaic from alternate photos in each flight line. If photo coverage is incomplete, initiate action to obtain additional photography.

Step 2. Enclose the study area on the photos with a rectangle of appropriate dimensions.

Step 3. Stereoscopically study each photo within the boundaries of the area enclosed above. Trace the alinement of all watercourses and water body shorelines within this area onto the overlay.** Include in this drainage network watercourses and gullies that carry water only during wet periods. For additional information on this procedure, refer to steps 2 and 3 of the watercourse and water body photo analysis section (4.2.2.1).

Step 4. Carefully check the drainage network to ensure that the alinement of all watercourses and water body shorelines visible on the photos are recorded on the overlay.

Step 5. Study the drainage network now depicted on the overlay. Outline each basin and then determine the overall hierarchy, i.e. primary, secondary, tertiary, of basins within the network. The basin classification concept used in this guide is outlined in step 6 of the map analysis section (4.3.1.1). Study this classification procedure and

*This procedure should be followed only if the tertiary basin of interest is not part of one of the secondary basins outlined on the map sheet.

**Check to see if the watercourses and water bodies factor overlay has been completed. If it has been completed, use it for watercourse alinement.

apply appropriate portions to analysis of the photo mosaic. Refer to figure 4.56, which is provided as an example of the basin delineation process. Note that given a detailed representation of the drainage net, such as that shown in figure 4.56, the basin delineation process is greatly simplified.

4.3.2.2 Assign identification nomenclature to each outlined basin. To accomplish this, refer to steps 1 through 4 of the map analysis section (4.3.1.2).

4.3.2.3 Complete the data requirements for Data Table 4. Primary Drainage Basins.

Step 1. For each primary basin outlined on the overlay, determine from alternate sources the name of the watercourse that forms the basin. Record this name in column 2.

Step 2. Use a topographic map to determine the major political units, e.g. borough, township, county, that have jurisdiction in the basin. Record these units in column 3.

Step 3. Use Procedure 5 (4.5.5) to determine the representative fraction (RF) of the photography.

Step 4. Determine the area of each primary basin.*

a. Follow the procedure outlined in step 3 of the map analysis section (4.3.1.3) to determine the number of square inches enclosed by the basin boundary.

b. Calculate the number of hectares per square inch at the scale of the photography:

Constant conversion expressions: 0.0254 m = 1 inch

$10{,}000\ m^2 = 1$ hectare

Example: RF of photography = 1:10,000

Calculate no. of meters per inch @ photo scale

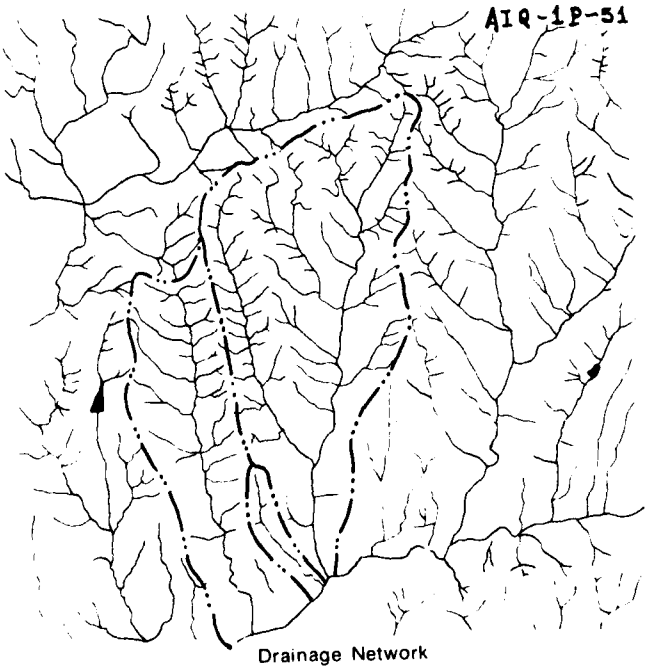
1 in. = 0.254 m x denominator of photo RF

= .0254 m x 10,000

= 254 m

*This procedure can also be applied to secondary and tertiary drainage basins.

Aerial Photo



Drainage Network

Figure 4.56 Aerial Photo and Drainage Network of Same Area with Several Drainage Basins Outlined.

Calculate no. of hectares per square inch @ photo scale

$$(1 \text{ in})^2 = (254 \text{ m})^2 \times \frac{1 \text{ hectare}}{10{,}000 \text{ m}^2}$$

$$= 64516 \text{ m}^2 \times \frac{1 \text{ hectare}}{10{,}000 \text{ m}^2}$$

$$= 6.5 \text{ hectares}$$

c. Determine the ground area (hectares) that the photo area determined above represents.

Example: Basin area = 3.4 sq. in.

1 sq. in. (photo area) = 6.5 hectares (ground area)

$$\text{basin ground area} = \frac{3.4 \text{ in}^2}{1} \times \frac{6.5 \text{ hectares}}{\text{in}^2}$$

$$= 22.1 \text{ hectares}$$

d. Round off the ground area value to the nearest tenth hectare and record it in column 4.

Step 5. Determine primary drainage channel length.*

a. If not already known, use Procedure 5 (4.5.5) to determine the representative fraction (RF) of the photography.

b. To facilitate measurement, mark off portions of the watercourse that are approximately straight (see figure 4.53).

c. Beginning with the furthest upstream segment, mark off its length of a separate piece of paper. Methodically advance the paper downstream. With each advance, add the adjacent straight line segment distance to that previously recorded on the paper. Progress the full length of the watercourse when its total channel length should be recorded on the paper.

d. Measure the channel length as recorded on the piece of paper.

e. Determine the actual length of the channel by multiplying the channel length measurement obtained above by the denominator of the photo's representative fraction:

*This procedure can also be applied to secondary and tertiary watercourses.

Example: Photo measured channel length = 25.2 cm

RF of photography = 1:10,000

Actual channel length = 25.2 cm x 10,000

= 252,000 cm

= 252 km

f. Round off the channel length value to the nearest tenth kilometer and record it in column 5.

Step 6. Determine the type and location of hydrologic structures.*

a. For background information, review stereograms 1 through 10 (appendix D) supplied with this guide as well as those portions of the Engineer Intelligence Guide #32 related to the photo-identification of hydrologic structures. Also review step 5 of the map analysis section (4.3.1.3).

b. Stereoscopically study each primary drainage basin and determine the type of each hydrologic structure present in the basin. Record the type, e.g. dam, levee, lock, in column 6.

c. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each structure. Record the coordinates in column 7.

Step 7. Determine the number of secondary and tertiary basins in each primary basin. Record the number of secondary basins in column 8 and the number of tertiary basins in column 9.

5.3.2.4 Complete the data requirements for Data Table 5. Secondary Drainage Basins

Step 1. For each secondary basin outlined on the overlay, determine from alternate sources the name of the watercourse that forms the basin. Record this name in column 2. If no name is given, write "unnamed" in the column.

Step 2. Determine the area of each secondary basin.

a. Use the procedure outlined in step 4 of section 4.3.2.3 to determine the area of each secondary basin.

b. Record basin area value to the nearest tenth hectare in column 3.

*Check to see if the watercourses and water bodies overlay has been completed. If it has, use it to locate the hydrologic structures.

Step 3. Determine the channel length of each secondary watercourse.

a. Before measuring the channel length of each secondary watercourse the analyst must extend the upstream portion of each channel to its respective basin boundary line. To do this, stereoscopically study the topography within each basin and thereby determine the most probable watercourse alinement to the boundary line.

b. Use the procedure outlined in step 5 of section 4.3.2.3 to measure the channel length. This is the distance measured from the point where the secondary watercourse enters the primary watercourse to the point where the extended watercourse intersects the basin boundary line. If the entire watercourse is not included in the study area, measure the distance from the point where the watercourse enters the primary watercourse to the point where it crosses the study area boundary line.

c. Round off the channel length value to the nearest tenth km and record it in column 4 of Data Table 5.

Step 4. Determine the type and location of hydrologic structures not recorded previously in Data Table 4.*

a. For background information, review stereograms 1 through 10 (appendix D) supplied with this guide as well as those portions of the Engineer Intelligence Guide #32 related to the photo-identification of hydrologic structures.

b. Stereoscopically study each secondary drainage basin and determine the type of each hydrologic structure present in the basin. Record the type, e.g. dam, levee, lock, in column 5.

c. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each structure. Record the coordinates in column 6.

4.3.2.5 Complete the data requirements for Data Table 6. Tertiary Drainage Basins.

Step 1. For each tertiary basin outlined on the overlay, determine from alternate sources the name of the watercourse that forms the basin. Record this name in column 2. If more than one watercourse is present in the basin, record the name of the one that drains the largest portion of the basin. If no name is given, write "unnamed" in the column.

---

*This procedure should be followed only if the secondary basin of interest is not part of one of the primary basins outlined on the overlay.

Step 2. Determine the area of each tertiary basin.

a. Use the procedure outlined in step 4 of section 4.3.2.3 to determine the area of each tertiary basin.

b. Record the basin area value to the nearest tenth hectare in column 3.

Step 3. Determine the channel length of the main watercourse in each tertiary drainage basin.

a. Identify the watercourse in each basin that drains the largest portion of the basin. This is the main watercourse and the one whose channel length should be measured.

b. As required, extend the upstream portion of each main watercourse to its respective basin boundary line. To do this, stereoscopically study the topography within each basin and thereby determine the most probable watercourse alinement to the boundary line.

c. Use the procedure outlined in step 5 of section 4.3.2.3 to measure the channel length. This is the distance measured from the point where the tertiary watercourse enters the secondary watercourse to the point where the extended watercourse intersects the basin boundary line. If the entire watercourse is not included in the study area, measure the distance from the point where the watercourse enters the secondary watercourse to the point where it crosses the study area boundary line.

d. Round off the channel length value to the nearest tenth km and record it in column 4 of Data Table 6.

Step 4. Determine the type and location of hydrologic structures not recorded previously in Data Tables 4 or 5.*

a. For background information, review stereograms 1 through 10 (appendix D) supplied with the guide as well as those portions of the Engineer Intelligence Guide #32 related to the photo identification of hydrologic structures.

b. Stereoscopically study each tertiary drainage basin and determine the type of each hydrologic structure present in the basin. Record the type, e.g. dam, levee, lock, in column 5.

c. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each structure. Record the coordinates in column 6.

*This procedure should be followed only if the tertiary basin of interest is not part of one of the secondary basins outlined on the overlay.

Step 5. Use Procedure 8 (4.5.8) to adjust the scale of the completed overlay to the scale of the 1:50,000 topographic map.

4.3.3 Literature Analysis

Because of the difficulty in determining the specific type of literature available for each analysis problem, it is impossible to provide detailed instructions for the use of scientific literature. When information gaps are encountered during the analysis, the analyst is encouraged to use appendix B1, which provides a number of suggested sources for water resources information.

4.4 Ground Water

The following paragraphs provide the steps necessary to complete the requirements for preparing the gound water overlay and supporting data tables using: 4.4.1 Topographic Map Analysis, 4.4.2 Photo Analysis, and 4.4.3 Literature Analysis. The procedures referred to under Topographic Map, Photo, and Literature Analyses are in section 4.5, "Supplementary Procedures".

4.4.1 Topographic Map Analysis

4.4.1.1 Use the following steps to record the location of wells and springs.

Step 1. Use Procedure 1 (4.5.1) to register the overlay material to the 1:50,000 topographic map.

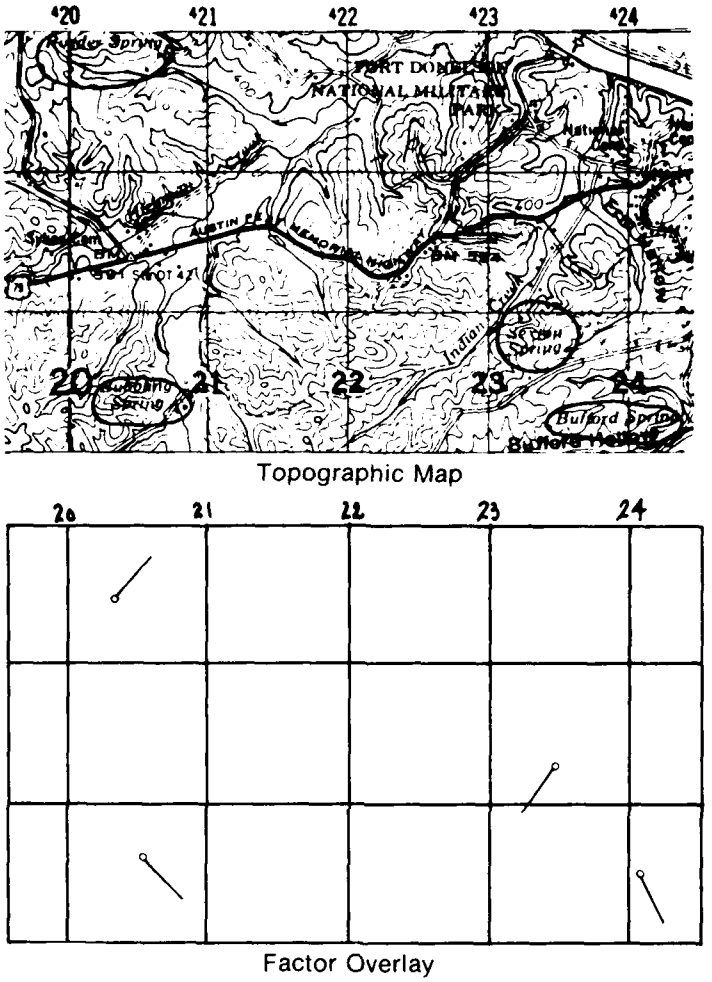
Step 2. Use Procedure 2 (4.5.2) to prepare the data tables.

Step 3. Starting in the upper left corner of the map sheet and working across and down, systematically identify and then symbolize all wells and springs on the overlay material.

Step 4. As necessary, refer to appendix A4 and Table 1. Overlay Representations of U.S. Inland Hydrography Symbols for symbolization instructions. Note that features shown as wells on 1:50,000 topographic maps include waterholes, walled-in springs, geysers, artesian wells, and fountains. Symbolize these features as wells on the overlay (see figure 4.57).

4.4.1.2 Use the following steps to assign an ID number to each well and spring recorded on the overlay.

Step 1. Number each well and spring consecutively, starting in the upper left corner of the overlay. Progress to the right and down in a normal reading manner.



Topographic Map

Figure 4.57 Topographic Map and Factor Overlay of Same Area with Springs Symbolized.

Step 2. Record these ID numbers in column 1 of Data Table 7.* Also record the type of feature, e.g. spring, geyser, waterhole, in column 2. If seasonality of the feature is given, i.e. intermittent or perennial, record this information in column 16.

Step 3. For each feature symbolized on the overlay, locate the name and record this name in column 3. If no name is given, write "unnamed" in the column.

Step 4. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each well and spring symbolized on the overlay. Record these UTM coordinates in column 4 of Data Table 7.

*See appendix A4, figure A11, Format for Ground Water Data Tables.

4.4.2 Photo Analysis

Aerial panchromatic photography, as well as other remote sensor data, cannot provide direct measurement of the ground water information needed to fulfill data table requirements. Ground water data that can be derived from aerial photography is primarily inferential and qualitative rather than quantitative (see Table 3 on the following page). Because of this, applying photo analysis to the factor overlay and data table production process is limited to preliminary, simple observations, such as identification of man-made features associated with ground water. These observations must be supported by quantitative information from other sources.

Step 1. Use Procedure 3 (4.5.3) to prepare a photo mosaic from alternate photos in each flightline.

Step 2. Study each photo stereoscopically and determine the location of man-made features associated with ground water. These features include canals and pump facilities for wells and improved springs. Also note the location of lush vegetative growth not in character with the adjacent vegetation. This anomalous vegetation growth may indicate the presence of a ground water discharge point, i.e. a spring.

Step 3. Compare the photo-derived overlay with the map-derived overlay, and note locations on the latter overlay where additional ground water information has been derived from the photos. Attempt to obtain quantitative information on these locations from other data sources.

4.4.3 Literature Analysis

4.4.3.1 Document Acquisition

Step 1. The literature analysis portion of the ground water study is perhaps the most important part of the entire study and the source of the greatest amount of ground water data. The initial step involves making a thorough literature search. The data may be located in the data base files or in one of the sources listed in appendix B1. Whatever the source, the analyst must attempt to obtain documents similar to the following:

a. Geological documents: maps, publications, articles in journals, documents existing in geological survey offices and in other departments and private firms;

b. Hydrological documents: publications; documents available from the above mentioned sources and from hydrogeological departments, including hydrogeological surveys (even brief ones) to locate water bearing areas, their estimated potential, and

Table 3. Representative Types of Observation and Inference of Geologic and Groundwater Conditions From the Study of Aerial Photographs

Type of Observation	Purpose of Observation
A. Water, or water features, at the land surface	Inference of ground-water conditions from surface-water conditions
1. Drainage density; subdivision of area on basis of drainage density	Classification of terrain on basis of relative permeability; differentiation of tracts of rather different permeability
2. Localized gain or loss of streamflow (e.g., springs and seeps along streams; sites or reaches of loss of water from channel)	Classification of streams as gaining or losing, and location of gaining and losing reaches; from this, inference of general nature of ground-water discharge, recharge, and circulation in near-surface rocks; together with geologic data, may permit inference of confined or unconfined aquifers, and of geologic controls on ground water
3. Seepage at land surface (commonly shown by character and distribution of vegetation)	Location of sites of ground-water discharge; areal form and areal and topographic distribution of these sites, together with geologic data, may permit inference of type of aquifer and of geologic controls on ground water
4. Presence and distribution of man-made water features (wells, improved springs, reservoirs, canals)	Show presence of water; with supplementary data, particularly relating to vegetation and land-surface drainage, may permit inference of effect of these water features on ground water in the area. (Photographs made before and after construction of features are particularly valuable)
B. Character and areal distribution of rocks	Inference of broad geologic controls on the occurrence of ground water
1. Specific type(s) of rock(s) as inferred from such evidence as landforms; texture, color, or tone of land surface; vegetation	Broad classification of types of water-bearing material near the land surface, and hence inference of probable porosity and relative permeability of near-surface material; with data on climate, vegetation, and drainage, inference of chemical quality of ground water
2. Spatial form and interrelations of rock units (stratigraphy and structure)	Inference of size, shape, and boundaries (lithologic and hydrologic) of probable aquifers and aquicludes, inference of conditions of recharge and discharge of ground water
3. Spatial relation of rock units to surface-water bodies	Inference of hydrologic boundaries and recharge conditions

Source: Manual of Remote Sensing, V II, p. 1525

depth of water; and documents on wells and springs, including information on location, yield, and water quality.

Step 2. Search through the literature obtained in step 1 and attempt to fill information gaps in the data tables. Attempt to locate quantitative information to support the observations made during the photo analysis. If information is found on the location of additional wells and springs, add these to the overlay. Read through the following sample extraction methods given below for highway boring logs and USGS Water Resources Data Reports.

4.4.3.2 Boring Log Analysis

Step 1. Obtain highway boring logs from local highway departments, engineering firms, or similar organizations and do the following:

a. Use the location information such as that shown in the sample boring log (figure 4.58) to plot the location of the boring on the factor overlay. Symbolize the boring as described in appendix A4.

b. Assign an ID number to each boring site. Start in the upper left corner of the overlay and work across and down in a normal reading manner. (This step may be performed later in the analysis sequence if it is anticipated that additional depth to water table information will be added to the overlay). Record the ID number in column 1 of Data Table 7.

Step 2. Use Procedure 4 (4.5.4) to determine the UTM coordinates of each boring. Record these coordinates (± 10 m) in column 4 of Data Table 7.

Step 3. Record the depth to water table information in column 10 of Data Table 7. Indicate in the remarks column (column 18) that this information was obtained from a highway boring log.

4.4.3.3 Water Resource Data Analysis

Step 1. Obtain the most recent U.S. Geological Survey Water Resources Data Report or similar document for the area of interest. When available, also obtain water resource documents for those years immediately preceding the most recent one.

a. Generally, a map will be provided with the document that shows the location of observation wells covered by the report (see figure 4.45). Study this map and determine which wells fall within the limits of the 1:50,000 topographic map.

Site No 2 Date October 12 197

Boring No G Job

Location 900 from culvert 60 in front of birch tree Supervisor

Elevation (Top of Boring) Drilling Foreman

Sampler(s) Group 3

DEPTH FROM	DEPTH TO	CLASSIFICATION AND REMARKS	SAMPLING NO	SAMPLING DEPTH	SAMPLING % MOISTURE
Ground surface	8	Organic - dark brown humus mixed inorganic-humus			
8	1	Dark organic humus material			
1	2 6	Gray clay dense iron content			
2 6	3	Organic dark humus			
3	3 6	Clay mixed with gravel boulder clay			
3 6	4	Clay and gravel coarse sand organic gap gratec			
		Roscommon series per MSHD drawing 00945A			
SPECIAL INSTRUCTIONS					

GROUNDWATER OBSERVATIONS	
DEPTH OF HOLE	4'
DEPTH TO WATER	2'
TIME OF OBSERVATION	

CASING NOTES			
FROM	TO	SIZE	REMARKS
Surface	4'	2"	

Figure 4.58 Boring Log Data.

b. Locate within the body of the report the observation wells of interest. Use the ground water level data, water quality data, and related well information to complete the Data Tables. The following steps illustrate the type of information that can be extracted from typical observation well data.

Step 2. Determine the UTM coordinates of each observation well.

a. Use the 15 digit identification number like that in figure 4.59 to determine the latitude and longitude of the well. The first six digits indicate the latitude in degrees, minutes and seconds. The eighth through thirteenth digits indicate the longitude in degrees, minutes, and seconds. Plot the location of the well on the overlay. Symbolize the well as described in appendix A4.

b. Use Procedure 4 (4.5.4) to determine the UTM coordinates of the well. Record these coordinates in column 2 of Data Table 8*.

*See appendix A4, figure A11, Format for Ground Water Data Tables.

Carter County

361738082132901. Local number Ct: H-1. Gap Creek Community. Near Elizabethton. Dug unused water-table well in Honaker Dolomite of Middle Cambrian age, diam 24 in (61 cm), depth 31 ft (9 m), casing information not available. Lsd 1,820 ft (555 m) above msl. MP top of concrete tile, 2.50 ft (0.76 m) above lsd. Highest water level 2.25 ft (0.69 m) below lsd, Mar. 16, 1973; lowest 26.01 ft (7.93 m) below lsd Dec. 22, 23, 1970. Records available: 1964-75.

Lowest water level for the day, from water-stage recorder, October 1973 to September 1974

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.
5	15.06	15.68	14.82	3.57	4.02	9.06	3.79	9.90	7.79	11.31	12.25	11.71
10	14.99	15.07	13.99	3.37	4.32	6.72	4.26	9.43	10.15	7.47	13.37	6.86
15	15.07	15.65	14.56	3.66	5.83	6.84	4.49	8.33	11.54	11.03	13.87	10.28
20	15.77	15.73	14.52	6.62	5.40	5.64	6.01	8.54	12.44	13.00	10.45	12.62
25	15.84	15.04	11.63	8.53	5.79	4.26	7.36	7.97	11.44	13.94	14.07	13.59
EOM	15.21	9.50	10.21	6.97	7.04	4.74	9.00	6.28	7.42	12.72	13.66	14.11

Figure 4.59 Observation Well Data.

Step 3. Assign an ID number to each observation well. Start in the upper left corner of the overlay and work across and down in a normal reading manner. Record the ID number in column 1 of Data Table 8.

Step 4. Use the narrative information like that at the top of figure 4.59 to determine diameter of the well (cm), well depth (m), highest and lowest water levels with respective dates of occurrence, the land surface datum (LSD) above mean sea level (m), and top of the well above LSD (m). Record this information in the appropriate columns of Data Table 8.

Step 5. Determine the mean water level for the well.

a. Calculate the mean of all water level measurements available for that well (for the data given, the mean is 10.2 ft or 3.1 m).

b. Record the mean water level to the nearest tenth of a meter in column 9, Data Table 8.

Step 6. Determine the UTM coordinates of observation wells used as water quality sampling sites. Use the procedure outlined in step 2. Refer to top of figure 4.60 for sample data.

Step 7. Symbolize each sample site on the overlay as described in appendix A4. Assign an ID number to each site. If necessary, adjust previously assigned well and spring ID numbers to accomodate the water sample site numbers. Record the ID numbers in column 1 of Data Table 7.

Step 8. Locate within the body of the report, each well's water quality information (figure 4.60). Transcribe the water

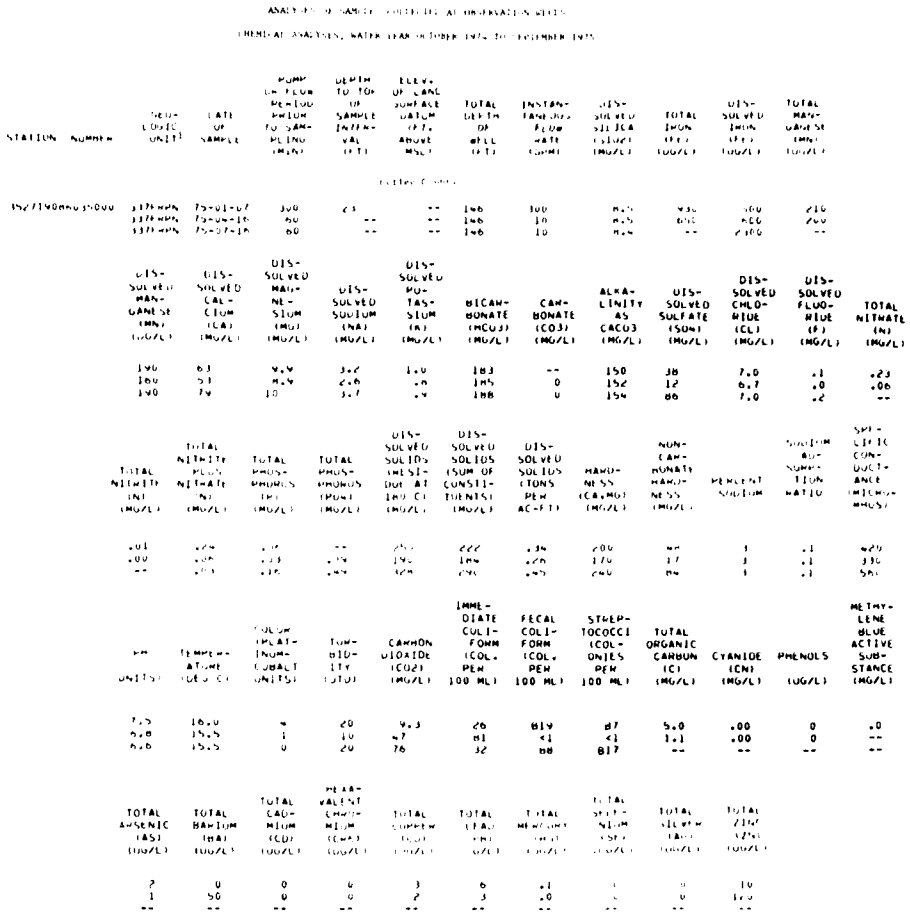


Figure 4.60 Ground Water Quality Data.

quality parameters and related site information to the appropriate columns of Data Table 7.

4.4.3.4 Contour Map Construction

Step 1. When sufficient ground water depths are known, construct a ground water elevation contour map on the overlay.* Remember, the contour map is constructed from mean depth to water table data. Seasonal influences will cause the actual level of the well to fluctuate both above and below this mean level.

*If data is inadequate for construction of a contour map, proceed to step 2.

a. Determine the elevation of each data point above mean sea level (MSL). Record these values on the overlay.

Solve for the value of x shown in figure 4.61. Subtract the height of the top of the well above land surface datum (LSD) from the mean depth to water table.

x = depth to water table - height of top of well above LSD

= 6.3 m - 0.3 m

= 6.0 m

Subtract the value of x from the LSD value to determine the water table elevation above MSL.

Elevation above MSL = LSD - x

= 217 m - 6 m

= 211 m

Use this value and others calculated similarly to construct the contour map.

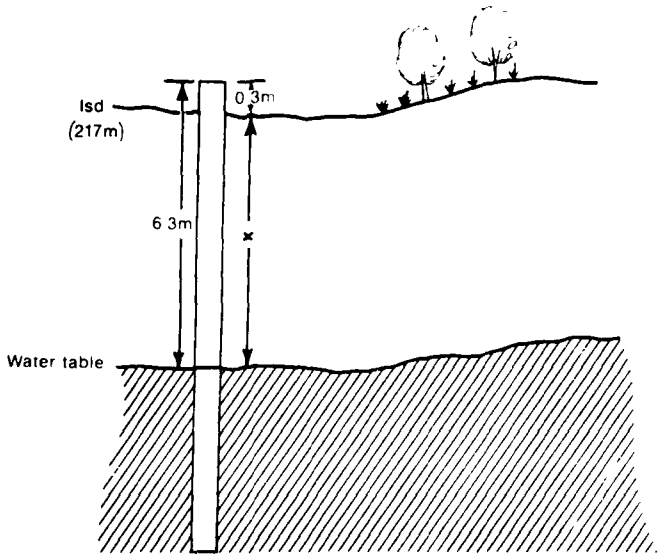


Figure 4.61 Well Profile.

b. Determine the appropriate contour interval (CI) for the map. Note the upper and lower limits of the water table depth data, e.g. 55 m (upper limit) to 101 m (lower limit). Choose a contour interval that will produce a reasonable number of contour lines (see figure 4.62).

c. Connect areas of terrain of equal water table elevation as shown in figure 4.62. (When interpolating between known water table elevation values, assume that a constant gradient exists between these known values.)

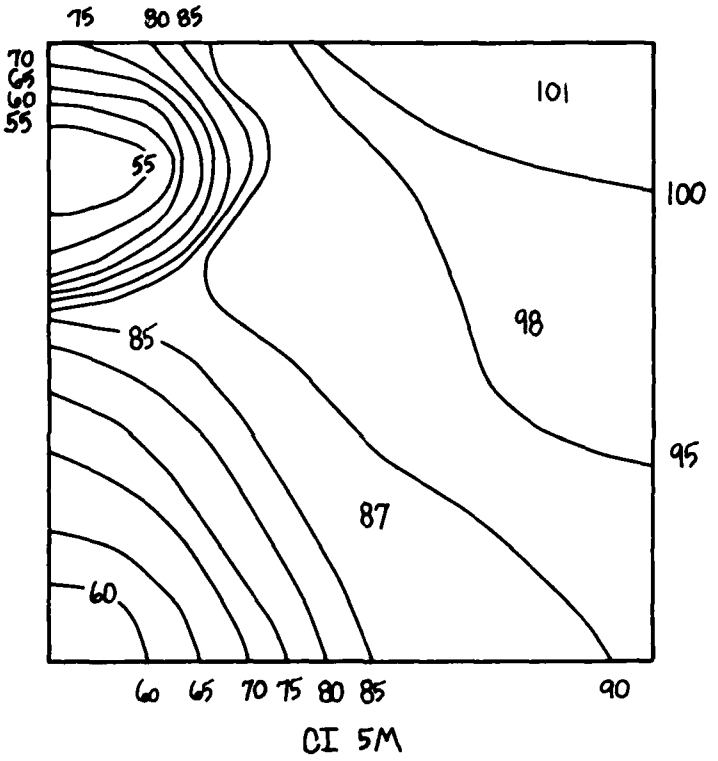


Figure 4.62 Ground Water Contour Map.

Step 2. Check to see that details of the completed overlay comply with one of the two overlay formats described in appendix A4. Also, check to see if any information was mis-recorded or left out of the Data Tables.

4.5 Supplementary Procedures

4.5.1 Procedure 1 - Registering Overlay Material to the 1:50,000 Topographic Map

Equipment and Materials

- Prismacolor pencils
- Masking Tape
- Straight Edge
- Light Table
- Frosted Mylar (K&E Herculene drafting film - 0.5 mm polyester base single matte or equivalent)
- Non-Abrasive Eraser
- Scissors
- 1:50,000 Topographic Map of Area of Interest

Step 1. On a light table or equivalent working surface, lay out the materials to be used in preparation of the overlay.

Step 2. Fasten each corner of the 1:50,000 topographic map to the working surface.

Step 3. Cut a piece of frosted mylar to a size slightly larger than the 1:50,000 topographic map.

Step 4. Fasten each corner of the overlay material over the 1:50,000 topographic map.

Step 5. Locate each map corner on the overlay with a registration tick.

Note: It may be helpful at later stages in the analysis if the map sheet neatlines and 10,000 meter grid lines are traced lightly in blue pencil on the overlay.

Step 6. Add the sheet name, number, and other marginal information as required in the appendixes.

4.5.2 Procedure 2 - Preparing Data Tables

Step 1. Obtain data table construction material. To facilitate diazo reproduction, construct the data tables from material similar to the overlay material, e.g. mylar. However, the material does not have to be a stable base as is required for the overlay.

Step 2. Prepare blank work sheets for the data field of interest, i.e. drainage basins, watercourses and water bodies, or ground water.

Step 3. Refer to the appropriate appendix for information concerning the specific format of each data table.

4.5.3 Procedure 3 - Preparing Aerial Photo Mosaics

All aerial photo mosaics should be constructed on a 4-by 8-foot, soft fiber board similar to such commercial products as "Homosote" or "Celotex". These materials will hold staples and can be used again as the areas are changed. During analysis this board can be placed on a layout table or on a pair of sawhorses supported by a sheet of plywood or planks.

Step 1. Separate the photos of each strip (flight line) into two stacks by pulling out alternate prints; photos 1, 3, 5, 7, form one group and photos 2, 4, 6, 8, form the second group. One group of photographs forms the mosaic, the other is used later in the analysis when stereo viewing is required.

Step 2. Sequentially lay out and overlap (approximately 10 percent) alternate photographs of the flight line that most closely bisects the center of the area of interest (either group of photographs may be used).

Step 3. Mosaic these photographs together, maintaining as closely as possible the geometric integrity of visible landscape features, i.e. aline streams, roads, ridge lines, etc. (do not fasten the photographs with staples at this time.)

Step 4. After mosaicking the central flight line, continue with the flight line on either side of the central one, and again lay out every other photograph. It may be necessary to re-aline previously mosaicked photographs to best aline linear features.

Step 5. Repeat the above procedure for each flight line. Continually readjust photographs to attain best fit.

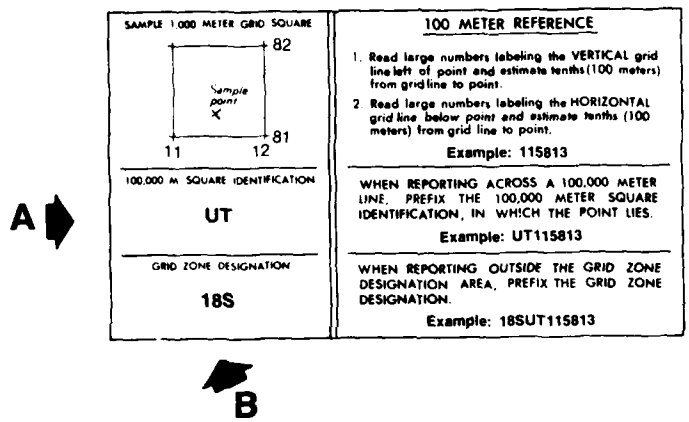
Step 6. When each flight line is mosaicked to your satisfaction, staple photograph corners to maintain alinement (see figure 4.63).

Step 7. Cut a piece of clear acetate or mylar of sufficient size to cover the mosaicked photography.

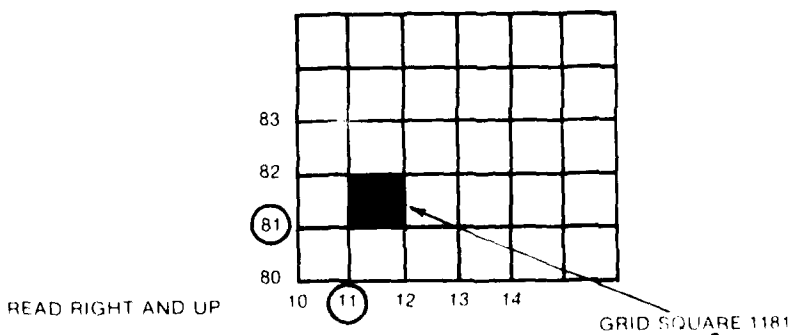
Figure 4.63 Photo Mosaic.

4.5.4 Procedure 4 - Determining UTM Coordinates

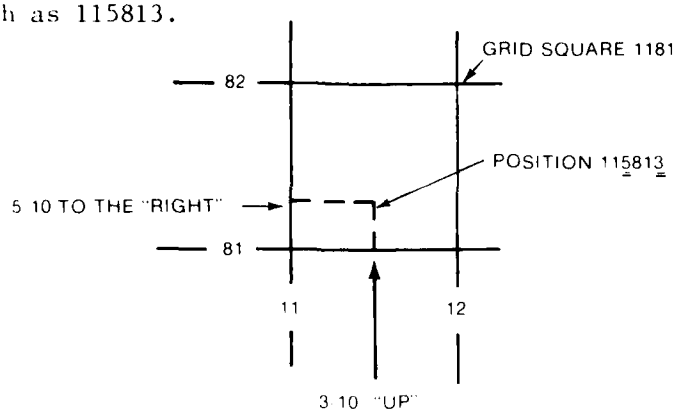
The U.S. Army, as well as NATO forces, use the Military Grid Reference Systems (MGRS) rather than latitude and longitude for identifying points on maps produced by the Defense Mapping Agency (DMA). This system employes the Universal Transverse Mercator (UTM) grid between 80° south and 84° north latitude. In the polar regions, north of 84° north latitude, and south of 80° south latitude, the Universal Polar Stereographic (UPS) grid is used. The MGRS system identifies a series of squares that get progressively smaller until a 100-by 100-meter square is reached. The largest of these squares is 100,000 meters on each side and is identified by two letters that place the square in a grid zone (see A and B below). Each grid zone is equal to 8° of latitude and 6° of longitude.



When you are locating a position on a large-scale topographic map, you are more interested in the 1,000-meter squares, called "grid squares." These are identified by a 4-digit number. You find the first two digits by reading the numbers on the bottom of the grid from left to right and, the second two by reading up, i.e. you read "right and up". This gives you the number of a grid square.



Now to find your location inside the grid square (to the nearest 100 meters), you need two mo.e digits, one for the horizontal axis and one for the vertical axis. So within the grid square, you extimate how many tenths of the way you are over to the right, and how many tenths of the way up you are. For example, suppose you are 5/10ths to the right and 3/10ths up, then you insert these to make a 6-digit number, such as 115813.



4.5.5 Procedure 5 - Determining Photo Representative Fraction (PRF)

Determining horizontal distances on vertical aerial photography requires that you find the scale or representative fraction (RF) of the photography. Normally, the scale or RF provided with the photography is not accurate enough for the measurements you will be making, since the scale varies with local terrain elevations or relief. It is important that you check the photographic scale for each area of the photo mosaic where horizontal measurements are required.

Calculate a representative fraction of the vertical aerial photography by one of the following methods:

4.5.5.1 Focal Length/Altitude Method

$$PRF = \frac{f}{H-h}$$

f = focal length of camera
H = altitude of aircraft
h = mean elevation of area covered by photography
PRF = RF of photo

Example: f = 6 inches (0.5 feet)
H = 10,000 feet
h = 150 feet (determined from map contour lines)

$$PRF = 1/x$$

$$1/x = \frac{0.5}{10,000-150}$$

$$1/x = 0.5/9,850$$

$$0.5x = 9{,}850$$
$$x = 19{,}700$$
$$\text{RF of photo} = 1/19{,}700$$

4.5.5.2 Photo Distance/Map Distance Method

$$\frac{PRF}{MRF} = \frac{Pd}{Md}$$

Pd = photo distance
Md = map distance
MRF = RF of map

Example: Pd = 0.432 feet
Md = 0.108 feet (scaled from map)

$$MRF = 1/50{,}000$$
$$PRF = 1/x$$
$$\frac{1/x}{1/50{,}000} = \frac{0.432}{0.108}$$
$$1/x = \frac{0.432}{0.108} \times 1/50{,}000$$
$$x = \frac{0.108}{0.432} \times 50{,}000$$
$$x = 12{,}500$$
$$\text{RF of photo} = 1/12{,}500$$

4.5.5.3 Photo Distance/Ground Distance Method

$$PRF = \frac{Pd}{Gd}$$

Pd = photo distance
Gd = ground distance
PRF = RF of photo

Example: Gd = 42 feet (known ground distance)

$$Pd = 0.007$$
$$PRF = 1/x$$
$$1/x = .007/42$$
$$.007x = 42$$
$$x = 6{,}000$$
$$\text{RF of photo} = 1/6{,}000$$

4.5.6 Procedure 6 - Determining Horizontal Distances On Vertical Aerial Photography

Step 1. Orient stereo pair for viewing. Securely fasten stereo mate (alternate photo) to the material overlaying the photo mosaic.

Step 2. Use a measuring device (graduated in millimeters) to determine the horizontal distance between the features of interest.

Step 3. Under stereoscopic viewing conditions, orient the device over the features to be measured (see figure 4.64). Measure and record the distance in millimeters.

Step 4. Calculate the horizontal ground distance by multiplying the photo value determined in step 3 by the denominator of the photo's representative fraction.

Example: Photo distance = 2.5 mm
RF of Photo = 1/20,000
Horizontal ground distance = (2.5 mm) (20,000)
= 50,000 mm

Convert this value to meters:
Constant conversion expression: 1 m = 1000 mm

$$\text{Horizontal ground distance} = \frac{50{,}000 \text{ mm}}{1} \times \frac{1 \text{ m}}{1000 \text{ mm}}$$

= 50 m

Illustration of Device for Measuring the Horizontal Distance Between Point A and Point B.

4.5.7 Procedure 7 - Determining Heights on Vertical Aerial Photography

Step 1. Orient stereo pair for viewing. Securely fasten stereo mate (alternate photo) to the material overlaying the photo mosaic.

Step 2. Orient a parallax measuring device over the highest point of the feature of interest and record this parallax value.

Step 3. Orient the device over the base of the feature or at ground level and record this parallax value.

Step 4. Subtract the parallax value recorded in step 2 from that recorded in step 3 to determine the parallax difference (Dp)

Example: Dp = Step 2 value - Step 3 value

= 0.236 ft - 0.233 ft

= 0.003 ft

Note: To reduce variability caused by a single measurement, make several measurements of parallax difference and average the results.

Step 5. Insert parallax difference (Dp) into the height formula and calculate the height of the feature of interest:

$$Dh = \frac{(H-h)(Dp)}{Bm + Dp}$$

Dh = height of feature

Dp = parallax difference

H-h = vertical distance between camera and the base of the feature

Bm = mean photographic base *

Example: Dp = 0.003 ft.

H = 6,000 ft.

h = 200 ft.

Bm = 0.335 ft.

$$Dh = \frac{(6000 - 200)(0.003)}{0.355 + 0.003}$$

$$= \frac{(5800)(0.003)}{0.358} = \frac{17.4}{0.358}$$

= 48.6 ft.

*The principal point of one photograph of the stereo pair is plotted on the other photograph, and the distance between centers is measured to obtain the value for Bm.

Step 6. Convert the calculated feature height to meters.

Example: feature height = 48.6 ft.

1 m = 3.3 ft.

$$\text{feature height (m)} = \frac{48.6}{3.3}$$

$$= 14.7$$

4.5.8 Procedure 8 - Scale Adjustments

When the boundaries of the various areas of interest have been delineated on aerial photography, they will have to be either enlarged or reduced to map scale, 1:50,000.

Use one of the following methods:

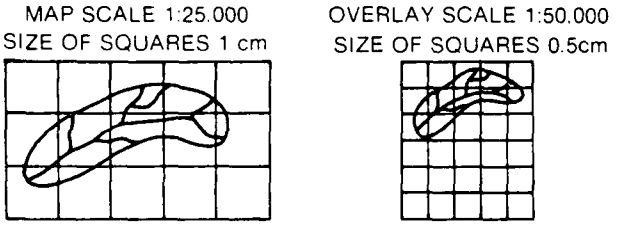
1. Have the mosaic overlay photographically enlarged or reduced to the overlay scale, and then trace the boundaries of the areas of interest onto the overlay. This method requires access to a large copy camera and a photographic laboratory which may not always be practical.

2. Use a relfecting projector to project the mosaic overlay onto the final overlay at the same scale, and then trace the boundaries. This will require that the overlay be folded and worked on in small sections.

3. Use a sketchmaster or zoom transferscope to transfer the boundaries. These instruments can be used only when the scale difference is small and can accommodate only small sections of the overlay.

4. Where available, a pantograph may be used.

5. As a last resort, the boundaries may be transferred by using a system of squares similar to the example below:



This method of transferring detail is very slow and should be used only when revising or completing small areas on the overlay.

APPENDIX A. SPECIFICATIONS FOR THE PREPARATION OF FACTOR OVERLAYS

A-1. Objectives and Design Elements Common to All Factor Overlays

A. Objectives

The objectives of this section are to establish the operational concepts for the production of factor overlays and to prescribe the design and formats for those elements and components common to all factor overlays.

B. Operational Concepts

1. Factor overlays are intended primarily for use within the mapping and intelligence community, and in addition as quick reaction terrain products for distribution to the user.

2. Factor overlays provide formatted geographic data that can be readily retrieved and used in various combinations for terrain analysis and for production of special terrain products.

3. Factor overlays will be prepared in the form of stable base overlays that will accept photographic reduction to 70 by 105 mm and retain their legibility when enlarged back.

4. Normally each data field will require several factor overlays for each area. Data elements to be portrayed on each factor overlay, the symbology to be employed, and unique formats are specified separately for each data field.

5. These specifications do not treat methods of collecting or reducing data. Their purpose is to specify the manner of graphically recording collected and reduced data.

C. Format

1. General format specifications are indicated in figures A1 and A2.

2. No single factor overlay will exceed 660 by 860 mm (26 by 34 inches), including titles, legends, and other marginal data. Where use of a base map exceeding these dimensions is desired, the base will be subdivided and separate factor overlays prepared for each part. When an oversized base is subdivided, each subdivision will be assigned an identification and an index of parts prepared as per figures A1 and A2.

3. Whenever possible, factor overlays will be registered to a standard scale U.S. military map. Base maps other than U.S. military maps will be clearly identified in the upper right corner of the factor overlay.

4. Each factor overlay will be punch registered to the base map at the four corners of the neatline.

5. A neatline 0.5 mm wide will be placed on each factor overlay. This neatline will normally coincide with the neatline of the base map.

6. Legend information will be placed on the areas identified as A, B, C, and D on figures A1 and A2 in that sequence. Area A will be used first, B second, etc. Where the legend is too large to be accommodated in the areas provided, it will be placed on a second piece of overlay material. This legend overlay will be prepared in the same format as the factor overlay and will bear the same identification data.

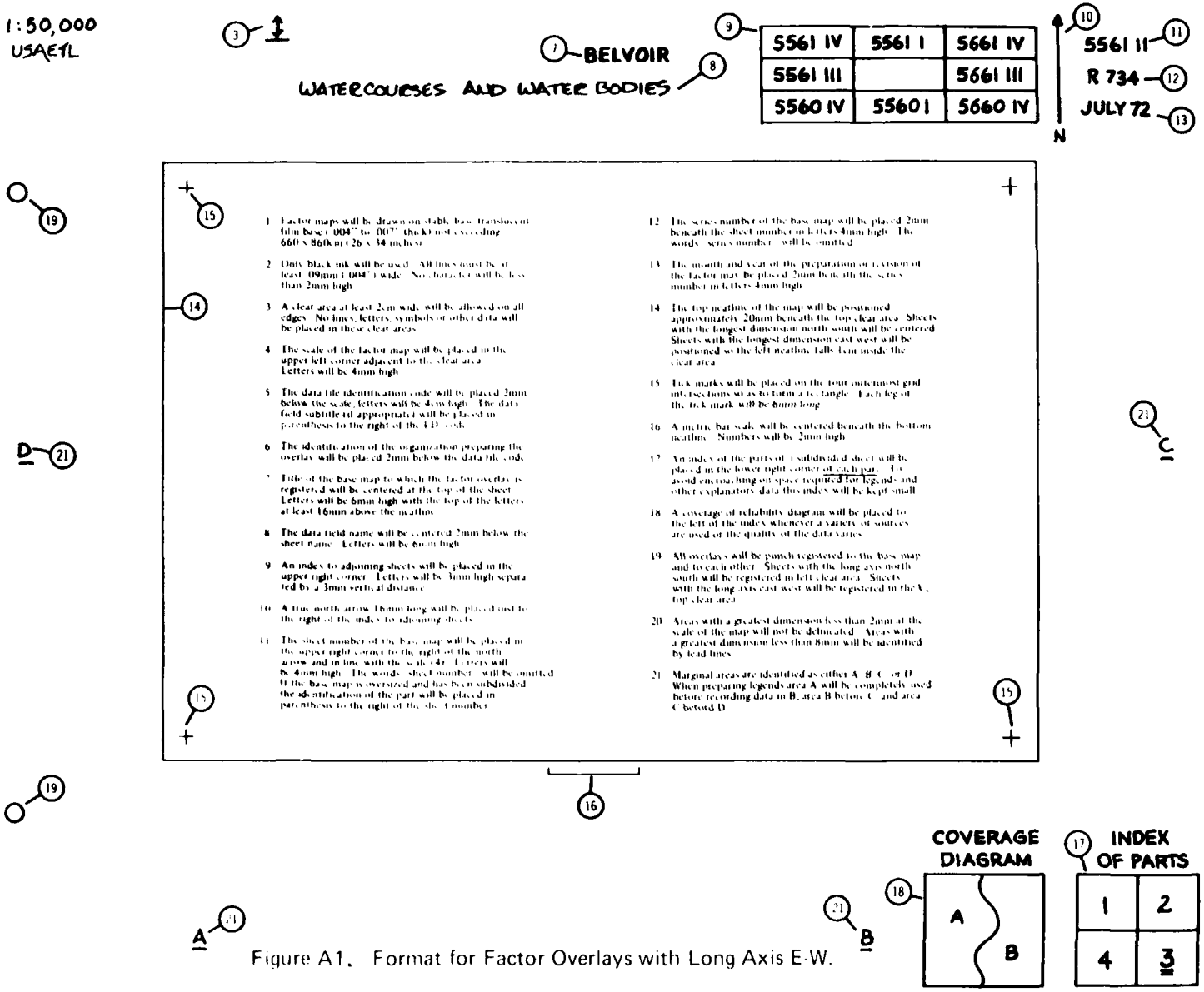


Figure A1. Format for Factor Overlays with Long Axis E-W.

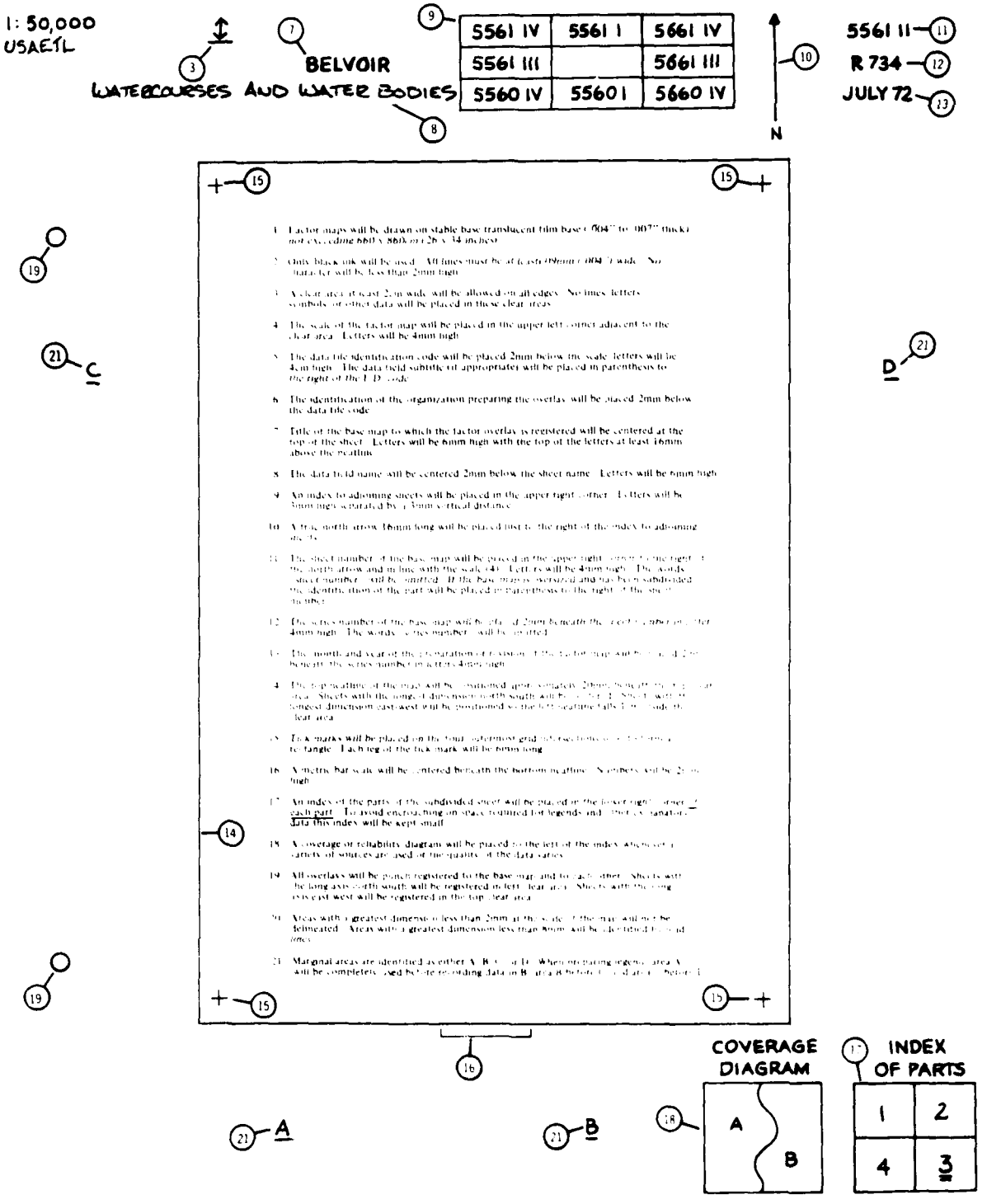


Figure A2. Format for Factor Overlays with Long Axis N S.

Copy available to DTIC does not permit fully legible reproduction

C. Symbolization

Symbols are specified separately for each data field. However, the following general guidelines will be followed.

1. All lines will be at least 0.09 mm (0.004") wide with a minimum spacing of 0.18 mm (0.008") between lines. When adjacent linear features would overlap if symbolized in their true position, the least significant feature will be displaced to provide the 0.18 mm clearance.

2. All letters will be at least 3.2 mm (0.125") high (Elite typewriter type).

3. All letters, numbers, and symbols will be positioned so as to be readable from the bottom or right side of the sheet.

4. All symbols, letters, and numbers will be drawn in black (plastic for mylar sheets) ink or black "Prisma" pencil.

5. Areas with a greatest dimension less than 2 mm will not be delineated. Areas with a greatest dimension less than 8 mm (.32") will be identified by lead lines.

6. Tick marks will be placed on the four outermost grid intersections so as to form a rectangle. Each leg of the tick marks will extend 3 mm from the intersection. These ticks are required to permit addition of the grid during the reproduction process.

A-2. Watercourses and Water Bodies

A. Introduction

1. This section prescribes the format and symbols to be used to prepare factor overlays for the data field watercourses and water bodies.

2. It is not anticipated that all data required by these specifications will be available during the initial preparation of a factor overlay. Lack of complete data, however, should not preclude preparation of the factor overlay. The factor overlay concept envisions the systematic recording of data as it is acquired, periodic revision of the overlays, and the accumulation of data over a period of time.

B. General Description

The watercourses and water bodies factor overlay will consist of two parts as follows:

1. An overlay registered to a 1:50,000 scale map (figure A3).

2. A series of accompanying data tables describing those features assigned ID numbers on the overlay as well as other related information (figures A4, A5, and A6).

C. Data Elements

The following data elements will be presented by the factor overlay and accompanying tables:

1. Factor Overlay

a. Alignment of all watercourses.

b. Shore alignment of all water bodies.

c. Terminal points and identification of watercourses with dry gap widths 3m or greater.

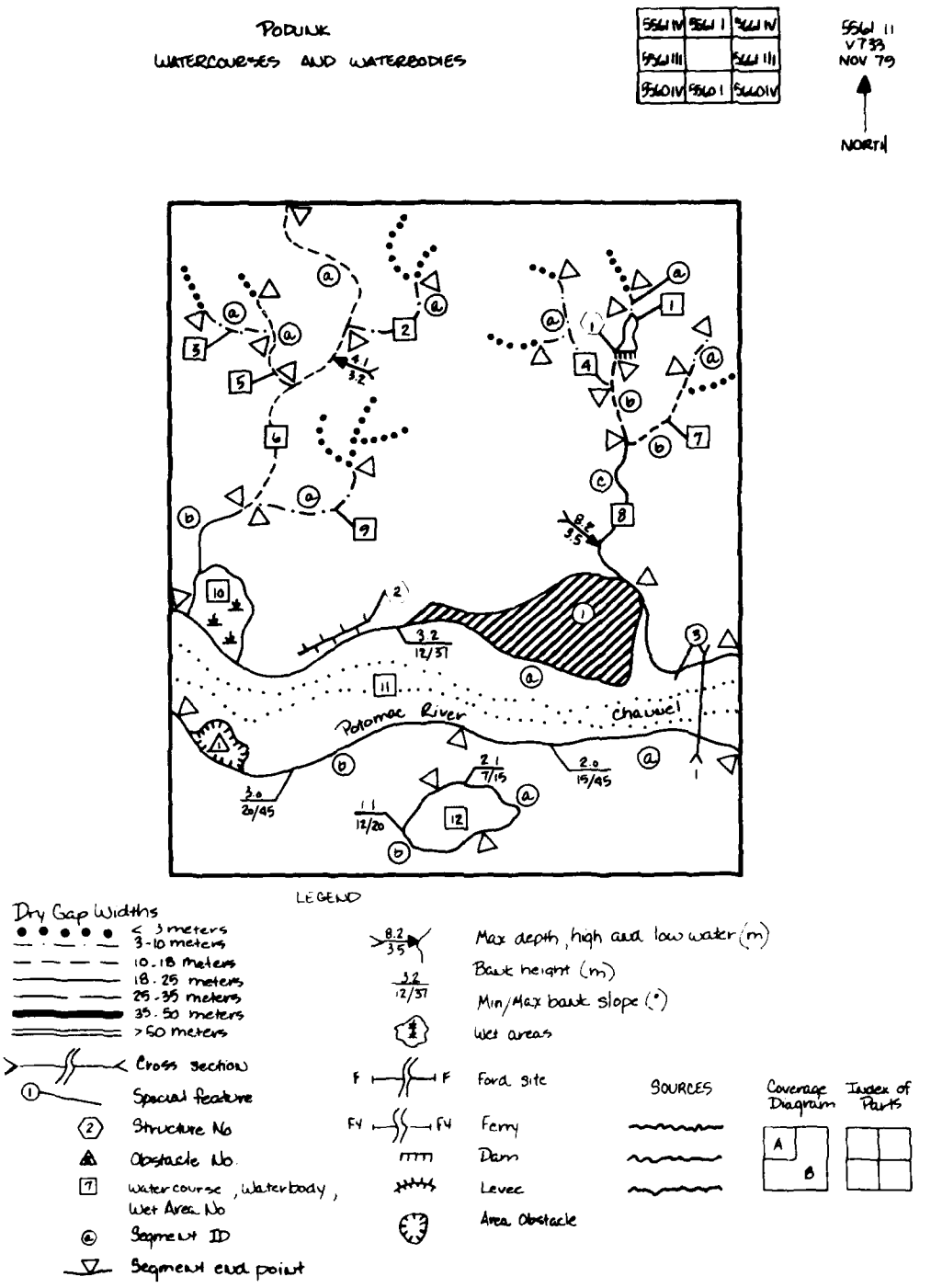


Figure A3. Format for Watercourse and Water Body Factor Overlay.

SCALE OF BASE MAP 1:50,000

USAETL

DATA TABLE 1 - WATERCOURSES AND WATERBODIES

5561 11
V733
NOV 79

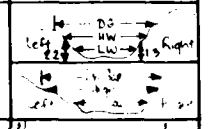
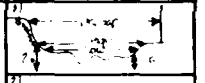
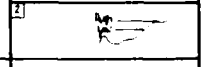
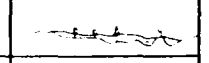
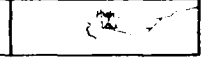
ID NO.	HYDROGRAPHIC FEATURE: LOCAL NAME	CLASS	SEG LETTER	LOW WATER WIDTH IN METERS	SEASONAL DEPTH WIDTH AND VELOCITY INFORMATION: HIGH WATER CONDITIONS: MONTH	DEPTH(m) MIN	DEPTH(m) MAX	WATER WIDTH IN METERS	VEL mps	LOW WATER CONDITIONS: MONTH	DEPTH(m) MIN	DEPTH(m) MAX	WATER WIDTH IN METERS	VEL mps	BANK INFORMATION: RIGHT BANK: HEIGHT IN METERS	SLOPE IN DEGREES MIN/MAX	MATERIAL	LEFT BANK: HEIGHT IN METERS	SLOPE IN DEGREES MIN/MAX	MATERIAL	MAX DISCHARGE cu m/s	CROSS SECTION SKETCH
1	Pohick Creek	Stream	a	8.1	Mar	2.2	2.7	6.2	2.1	Aug.	1.7	2.5	3.1	0.5	2.0	15/31	GC-CH	1.5	10/32	Cu.GP	740	
			b	12.4	Mar	3.0	4.1	6.5	2.3	Aug.	2.0	3.1	3.3	0.5	3.0	19/19	CH STONE	2.0	5/20	SMCL	740	
2	Potomac River	River	a	2500.0	Jan, Feb	20	22	2200	2.0	Oct	15	17	2100	1.0	4.0	25/60	Rock	—	—	—	1500	
			a	2500.0	Jan, Feb	18		2400	2.0	Oct	2.0		2200	1.0	—	—	—	2.0	15/45	SC	1500	
			b	2600.0	Jan, Feb	25	29	2400	2.0	Oct	2.0	2.9	2250	1.0	—	—	—	5.0	20/45	SC	1500	
3	Great Swamp	Swamp	—	—	Apr	1.0	1.2	—	—	Sept	0.5	Dry	—	—	—	—	—	—	—	—	—	
4	Walden Pond	Pond	a	2.0.0	Apr	2.0	2.8	15	<1	Sept	1.0	1.5	12	<1	1.0	15/40	CH	—	—	—	—	

Figure A4. Format for Data Table 1 – Watercourses and Water Bodies.

DATA TABLE 2 - WATERCOURSES AND WATERBODIES

HYDROGRAPHIC FEATURE				BOTTOM CONDITIONS		TIDAL INFLUENCE			WATER QUALITY					ICE CONDITIONS													OBSTACLES	
														NO. OF ICE DAYS PER MONTH												MAX ICE THICKNESS (CM)		
ID NO	LOCAL NAME	CLASS	SEG NO	MATERIAL	SLOPE IN DEGREES	MAX MO'S	MIN MO'S	DAILY RANGE IN METERS	ID NO	SAMPLE DATE	ANALYSIS CHEM	ANALYSIS PPM (MG/L)	GEN CLASS	1	2	3	4	5	6	7	8	9	10	11	12		ID NO	DESCRIPTION/SKETCH
1	Jonick Creek	Stream	a	CL some Boulders	3a	3,8	6,12	0 7	1	10-71	CA Mg Na Mnc Cl F	44 12 69 17 70 15	Brackish Polluted	6	8	5	-	-	-	-	-	-	-	2	2	30	1	Wind Fall Trees
			b	CH Some Boulders	30	3,8	6,12	0 3	2	1-72	Mg	60 110	Brackish Polluted	6	8	5	-	-	-	-	-	-	-	2	2	20		
2	Potomac River	River	a	Clover SC	2	3,8	6,12	0 5	3	10-70	CA F Cl	60 10 50	Brackish	5	6	-	-	-	-	-	-	-	-	1	1	20	3	Sunken Barge 4x10x3 Meters at 1345 5126
			a																									
			b	Clover Rock	2	3,8	6,12	0.5	-	—	-	—	Brackish	5	6	-	-	-	-	-	-	-	-	-	-	20	4	Submerged Rocks
3	Great Swamp	Swamp	—	OH DT Over CL	<1	3,8	6,12	0 2	5	1-72	—	—	High Coliform Count	7	6	6	-	-	-	-	-	-	-	-	-	30	-	WOLVE
4	Walden Pond	Pond	a	CH	<1	—	—	-	4	12-72	Mncl Board Cl	16 110 200 20	Fresh	7	6	6	-	-	-	-	-	-	-	-	-	30	-	Reeds near shore

Figure A5. Format for Data Table 2 – Watercourses and Water Bodies.

DATA TABLE 3 - WATERCOURSES AND WATERBODIES

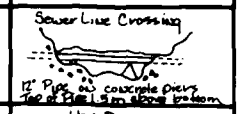
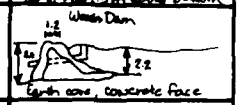
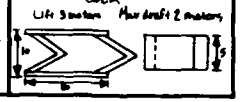
HYDROGRAPHIC FEATURE				NAVIGATION INFORMATION											AREAS SUBJECT TO FLOODING					STRUCTURES & SPECIAL FEATURES	
				NAVIGATION SEASON			CLEARANCES														
							MIN VERTICAL IN METERS			MIN HORIZONTAL IN METERS			MAX DRAFT IN METERS								
ID NO	LOCAL NAME	CLASS	SEG NO	OPEN DATE MO DAY	CLOSE DATE MO DAY	CAUSE	UTM COORD	LOW W	HIGH W	UTM COORD	LOW W	HIGH W	LOW W	HIGH W	ID NO	LAST DATE	MEAN DEPTH (m)	DURATION (DAYS)	CAUSE	ID NO	DESCRIPTION/SKETCH
1	Pohick Creek	Stream	a	—	—	—	—	—	—	—	—	—	—	—	1	6/72	2.0	3	Heavy Rains	1	
			b	2/15	12/20	Ice	82264018	4.0	2.0	82264018	5.0	5.0	0.5	1.5			None	on segment		2	
2	Potomac River	River	a, b, c, d, e	2/1	12/20	Low Water	92263019	5.0	3.1	92263019	1000	1000	5.0	7.0	2	6/72	3.0	6	Ice Jam	4	Numerous Small Boat Docks
																				6	

Figure A6. Format for Data Table 3 – Watercourses and Water Bodies.

d. Terminal points and identification of watercourse segments with dry gap widths 3m or greater.

e. Dry gap widths, by classes, of watercourses with gap widths 3m or greater.

f. Average maximum depth during seasonal high and low water periods.

g. Bank heights and min/max slopes above mean water for watercourses with gap widths greater than 50m and water bodies.

h. Delineation of wet areas.

i. Structures and special features/areas.

j. Point and area obstacles.

k. Areas subject to flooding.

l. Location of watercourse cross sections.

m. Navigation channels.

n. Location of fords and ferries.

2. Data Tables

a. Classification of watercourses, water bodies, and wet areas.

b. Wet and dry gap widths.

c. High and low water conditions.

d. Water velocity and maximum discharge.

e. Bank and bottom information.

f. Representative watercourse cross sections.

g. Tidal influence.

h. Water quality information.

i. Ice conditions.

j. Descriptions/sketch of point and area obstacles.

k. Navigation information.

l. Description of areas subject to flooding.

m. Description/sketch of hydrologic structures and special features/areas.

D. Format

1. Factor Overlay (figure A3)

a. The general format for the factor overlay will be as described in section A-1 of this appendix.

b. Source(s) used in the preparation of the factor overlay and tables will be entered in section B (figures A1 and A2) to the left of the coverage diagram when they are not adequately described in the coverage diagram. Where a single source is used, or all sources apply to the entire sheet, the coverage diagram may be replaced by the source listing.

2. Data Tables (figures A4, A5 and A6)

a. The general format of the data tables will be as prescribed in section A-1 of this appendix.

b. Where the number of entries will permit, the watercourse and water body Data Tables will be placed on a single overlay. When the amount of information is too great to permit placing all tables on a single overlay, a separate overlay will be prepared for each table.

E. Symbolization

The following symbology will be used on the factor overlay:

1. Terminal points for watercourses

Terminal points are defined as:

a. The points where the watercourse crosses the map neatline.

b. The point at which the dry gap width becomes 3m or greater.

c. The point at which the watercourse loses its identity by entering a water body or larger watercourse or where the watercourse regains its identity by emerging below a dam.

d. The symbol is not used for watercourses with dry gap widths less than 3 meters or for water bodies.

2. Watercourse/Water Body/Wet area identification

a. Watercourse identification will be shown only for watercourses with gaps 3 meters or greater in width.

b. Wet areas include swamps, marshes, bogs, paddy/wet crops, etc.

c Watercourses, water bodies, and wet areas will be numbered sequentially within each map sheet.

d. Where space will permit, the symbol will be placed within the open water or wet area. For small watercourses, the symbol will be placed astride or adjacent to the watercourse. Lead lines will be used for small water bodies or short watercourses. The size of the box may be adjusted to accommodate the number of digits in the identifier.

e. The watercourse name, where shown on the base map, may be placed parallel to the watercourse in approximately the same size lettering as used on the base map. Names will not be used on the overlay where they would clutter the overlay or obscure other data.

3. Start/End points of watercourses and water body segments

a. In the case of watercourses with dry gap widths 50 meters or less, segments are selected primarily on the basis of the watercourse width class. However, extreme changes in bank, depth, bottom, or velocity conditions may also be reasons for establishing a segment.

b. Segments for water bodies and watercourses greater than 50 meters wide will be selected on the basis of bank heights.

c. A separate series of segments will be established for each side of watercourses with gap widths greater than 50 meters.

4. Segment identification

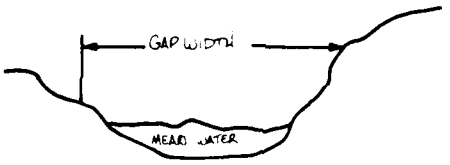
a. Segments will be assigned lower case alphabetical identifiers starting with the first upstream segment.

b. Segments for watercourses with gap widths 50 meters or less will include both banks.

c. Separate segments will be required for each bank for water bodies and watercourses with gap widths greater than 50 meters, i.e., there will be a separate series of segments for each bank. See sample treatment on figure A4.

5. Watercourse widths

Gap width is defined as the horizontal distance, bank to bank measured at the first slope break above mean water level (see illustration below).



a. Watercourses with gap widths less than 3 meters.

b. Watercourses with gap widths 3 - 10 meters.

c. Watercourses with gap widths 10 - 18 meters.

d. Watercourses with gap widths 18 - 25 meters.

e. Watercourses with gap widths 25 - 35 meters.

f. Watercourses with gap widths 35 - 50 meters.

g. Watercourses with gap widths greater than 50 meters and all water body shorelines are drawn to scale.

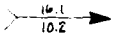
6. Bank conditions

a. Bank conditions are shown for each bank segment of watercourses 50m or greater in width and water bodies where sufficient space is available for recording this information.

b. Numerator indicates bank height above mean water to the nearest tenth meter.

c. Denominator indicates min/max bank slope in degrees.

7. Maximum water depth



a. Numerator indicates average maximum depth in meters during seasonal high water periods.

b. Denominator indicates average maximum depth in meters during seasonal low water periods.

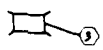
8. Location of watercourse cross section

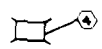
[illegible] be used wherever required to illustrate the watercourse.

b. Identifying [illegible] ence to Data Table 1.

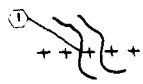
9. Structures and special features

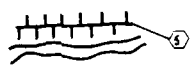
Identifying number is used as a cross reference to data tables.

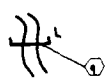
a. Bridges 

b. Tunnels 

c. Dams

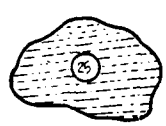
d. Cable crossings 

e. Levees 

f. Locks or lifts 

g. Special feature described in data tables, e.g. navigation aids, location of gaging stations, etc.

h. Special area described in data tables, e.g. sewage disposal and filtration beds, fishponds and hatcheries, glaciers, etc.



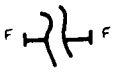
10. Obstacles

a. Number identifies the obstacle and serves as cross reference to data tables.

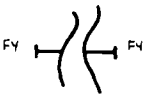
b. Where the watercourse or water body is large enough, obstacles may be symbolized or noted within the water area. Symbols will be sketch versions of those appearing in AMS TM S-1, Chap. 6, Sec VIII.

11. Crossing sites

a. Fords



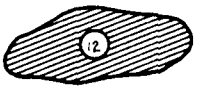
b. Ferries



12. Navigation channels

Channels will be shown only for those watercourses large enough to permit symbolization by a double line.

13. Areas subject to flooding



a. Area boundary indicates maximum extent of flooding.

b. *Number identifies area within the map sheet and serves* as reference to data tables.

14. Water quality sample sites

Point at which water sample taken.

F. Data Tables

1. Data Table 1

Data appearing in this table will be referenced to watercourses, water bodies, and wet areas identified on the overlay.

a. The watercourse, water body, and wet area identification numbers will be assigned sequentially within the map sheet. These numbers will be assigned starting in the upper left hand corner of the overlay and progressing across and down the overlay.

b. The feature names will be taken from the map to which the overlay is registered.

c. Hydrographic features will be classified into one of the following categories:

(1) River

(2) Stream

(3) Inland Waterway

(4) Aqueduct, Penstock, Pipeline, Flume

(5) Canal (navigable, abandoned, under construction)

(6) Irrigation canal/ditch

(7) Drainage canal/ditch

(8) Lake

(9) Pond

(10) Inland Sea

(11) Marsh

(12) Swamp

(13) Paddy/Wet Crops

(14) Salt Pan

(15) Reservoir

(16) Lagoon

d. Segments will be assigned identifying lower case letters starting at the first upstream segment. Where there are more than 26 segments, two letters, e.g. aa, bb, will be used for segments 27 and above.

e. The dry gap width will be recorded to the nearest tenth meter. Widths will be measured horizontally between the first slope breaks above mean water.

f. The months during which high water conditions are most likely to occur will be indicated by entering the abbreviations for the months, e.g. Mar for March, Jun for June, etc.

g. Maximum and minimum water depth during average high water conditions will be recorded to the nearest tenth meter for each segment. If the watercourse is completely dry during a part of the season, it will be noted.

h. Width of the water gap during high water conditions will be recorded to the nearest tenth meter.

i. Water velocity during high water conditions will be recorded in meters per second.

j. Low water conditions will be recorded in the same fashion as for high water.

k. Bank heights will be recorded to the nearest tenth meter measured between mean water and the first slope break.

l. Bank slopes will be recorded in degrees.

m. Bank material will be indicated by recording either the unified soil classification or a word description such as rip rap, masonry, rock, bituminous, etc.

n. The maximum flow in cubic meters per second (cu m/s) for period of record will be recorded whenever the information is known or can be estimated.

o. The segment cross section may be either a representative sketch or an actual cross section. Where actual cross sections are used the location will be indicated on the overlay.

2. Data Table 2

a. The feature number and name and the segment identification letter will be recorded in the same manner as Table 1.

b. Bottom conditions are indicated by recording the bottom material in unified soil classification system symbols or word description and slope of the watercourse in degrees.

c. Tidal influences, if any, are indicated by entering number codes for the months during which the maximum influence occurs, e.g. 1 for Jan., 2 for Feb., etc.

d. The mean daily tidal range within a segment will be recorded to the nearest tenth meter.

e. The water quality sample number will appear on the overlay and in the data table. The date the sample was taken will be recorded in the table if known.

f. The water analysis will indicate the type of contaminants **and the parts per million (ppm) or milligrams per liter (mg/l) for each.**

g. Each sample will be assigned a general classification as follows:

(1) Fresh - less than 500 ppm dissolved solids

(2) Brackish - 500 - 15,000 ppm dissolved solids

(3) Salt - greater than 15,000 ppm dissolved solids

(4) Polluted - Polluted by sewage, agricultural, or industrial wastes.

h. The mean number of days of icing during each month will be indicated by recording a number in the column beneath the appropriate month. The month during which the heaviest icing occurs will be circled.

i. The maximum ice thickness occurring during the year will be recorded in centimeters.

j. Obstacles will be described by recording the obstacle number from the overlay and providing a sketch or brief narrative description.

3. Data Table 3

a. Feature number and name and the segment identification letter will be recorded in the same manner as Table 1.

b. Open and closing dates for navigation will be recorded for those hydrographic features known to be frequently used for navigation.

c. The reason for closing a segment to navigation will be recorded in the form of a brief statement, i.e. ice, flood, maintenance, etc.

d. The location of minimum vertical and horizontal clearances will be recorded in UTM coordinates to the nearest 10 meters.

e. The minimum vertical and horizontal clearances will be given to the nearest meter.

f. The maximum draft of vessels which can navigate the channel during mean water will be given to the nearest 0.5 meter.

g. The identification number of areas subject to flooding will be taken from the overlay.

h. If known, the date of the most recent flood will be recorded.

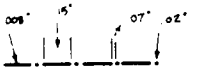
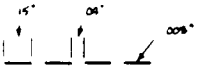
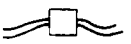
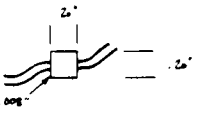
i. The mean depth within the flooded area will be recorded to the nearest tenth meter.

j. The past duration of the flood will be recorded in days.

k. The cause of flooding will be recorded, i.e. heavy rain, ice jams, broken dam, etc.

l. Structures and special features will be described by recording the identification number and providing a sketch or narrative description or both. Structures and features to be treated here include: dams, tunnels, locks, lifts, levees, inclined planes, etc.

SYMBOLIZATION

WATERCOURSES	SYMBOL	DIMENSIONS
Dry Gap Width		
< 3 meters		
3 - 10 meters		
10 - 18 meters		
18 - 25 meters		
25 - 35 meters		
35 - 50 meters		
> 50 meters		
Watercourse start and end points		
Watercourse identification number		

Watercourse segment start and end points

Watercourse segment identification

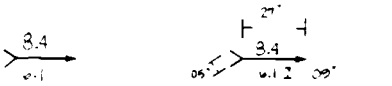
Elevated aqueduct, penstock, pipeline, or flume

Underground aqueduct

Location of cross section

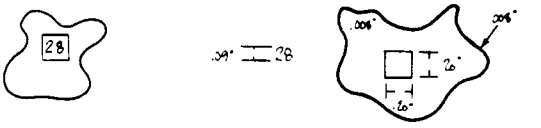
Bank height in meters
Min/Max bank slope in degrees

Maximum water depth.
Numerator, depth at high water to nearest tenth meter; denominator, depth at low water to nearest tenth meter.

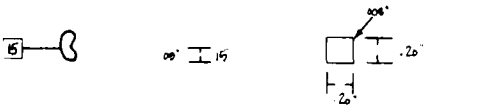


WATER BODIES

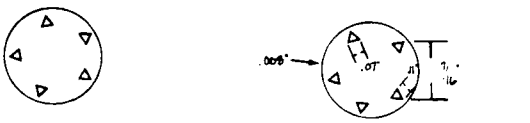
Identification No.
Large Bodies



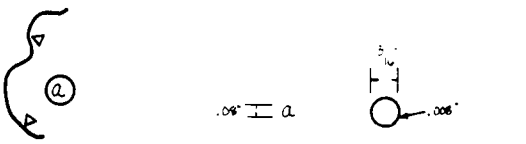
Identification No.
Small Bodies



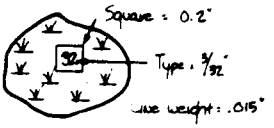
Bank segment start/ end points



Bank segment identification



Wet Areas

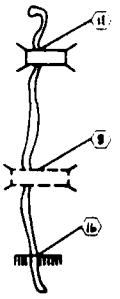


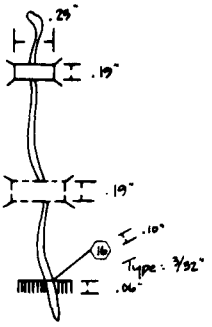
STRUCTURES & SPECIAL FEATURES

Bridges

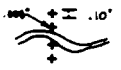
Tunnels

Dams

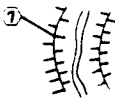


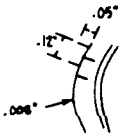


Cable crossing

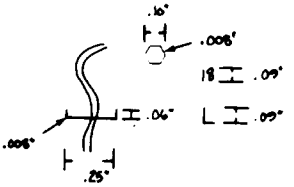


Levees and other flood control structures

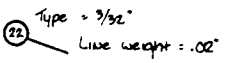




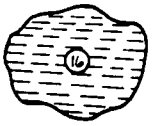
Locks, lifts and other hydraulic structures

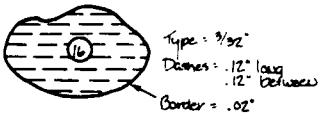


Special feature



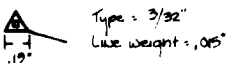
Special area



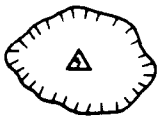


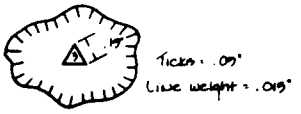
OBSTACLES

Point Obstacle

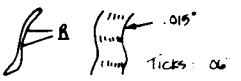


Area Obstacle

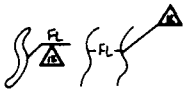


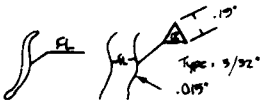


Rapids



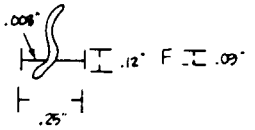
Falls



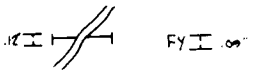


CROSSING SITES

Fords

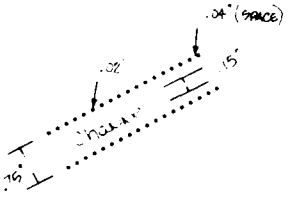


Ferries

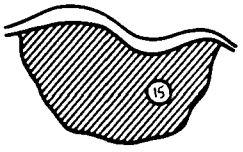


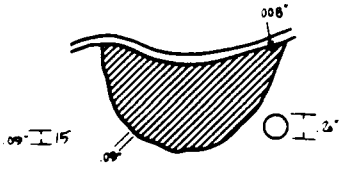
NAVIGATION CHANNELS

(Shown only for larger streams)



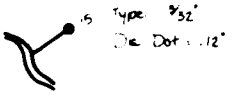
AREAS SUBJECT TO FLOODING





WATER QUALITY SAMPLE SITES

Point at which water sample taken



A-3. Drainage Basins

A. Introduction

1. This section prescribes the format and symbols to be used to prepare factor overlays for the data field drainage basins.

2. It is not anticipated that all data required by these specifications will be available during the initial preparation of a factor overlay. Lack of complete data, however, should not preclude preparation of the factor overlay. The factor overlay concept envisions the systematic recording of data as it is acquired, periodic revisions of the overlays, and the accumulation of data over a period of time.

B. General Description

The drainage basin factor overlay will consist of two parts as follows:

1. An overlay registered to a 1:50,000 scale map (figure A7).

2. Three accompanying data tables describing those features assigned ID numbers on the overlay as well as other related information (figure A8).

C. Data Elements

The following data elements will be presented by the factor overlay and accompanying tables:

1. Factor overlay

a. Alinement of all watercourses.

b Delineation of the boundaries of primary, secondary, and tertiary drainage basins.

c. Letter identification of each primary and secondary drainage basin.

d. Alphanumeric identification of each tertiary drainage basin.

2. Data Tables

a. Data Table 4 - Primary Drainage Basins

(1) Identification symbol (single letter) and name of primary drainage basin.

(2) Name(s) of political unit(s) located within the basin's boundaries.

(3) Total surface area of the drainage basin (hectares).

(4) Length of primary basin channel (km).

(5) Type and location (UTM coordinates) of hydrologic structures.

(6) Number of secondary drainage basins.

(7) Number of tertiary drainage basins.

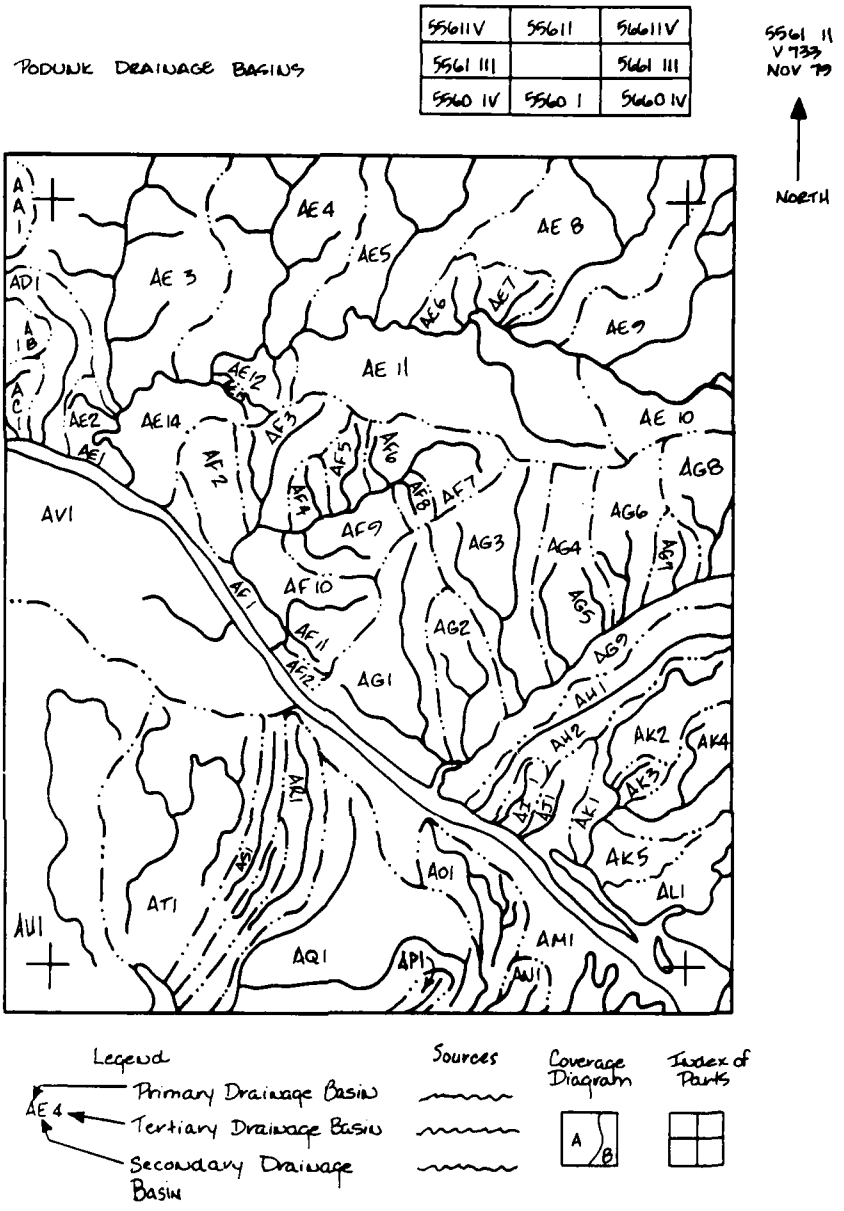


Figure A7. Format for Drainage Basin Factor Overlay.

DATA TABLE 4 - PRIMARY DRAINAGE BASINS

1	2	3	4	5	6	7	8	9
ID	Name	Political Unit(s)	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures		No. of Secondary Drainage Basins	No. of Tertiary Drainage Basins
					Type	UTM Coord		
A	Susquehanna River	Moore Co	56 3	6 2	Concrete Dam	922630	2	5

DATA TABLE 5 - SECONDARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures	
				Type	UTM Coord.
AA	Swatara Creek	19 1	2.1	None	
AB	Wilson Creek	37.4	3.1	See Table 4	

DATA TABLE 6 - TERTIARY DRAINAGE BASINS

1	2	3	4	5	6
ID	Name	Basin Area (Hectares)	Channel Length (km)	Hydrologic Structures	
				Type	UTM Coord.
AA 1	Smith Creek	12.2	1.1	None	
AA 2	Salmon Creek	7.3	0.4	None	
AB 1	Shell Creek	17.5	1.6	See Table 4	
AB 2	Red Creek	5.2	0.3	None	
AB 3	Mill Creek	15.1	2.1	None	

Figure A8. Format for Drainage Basin Data Tables.

b. Data Table 5 - Secondary Drainage Basins

(1) Identification symbol (double letter) and name of secondary drainage basin.

(2) Total surface area of the drainage basin (hectares).

(3) Length of secondary basin channel (km).

(4) Type and location (UTM coordinates) of hydrologic structures not recorded in Data Table 4.

c. Data Table 6 - Tertiary Drainage Basins

(1) Identification symbol (letters and number) and name of tertiary drainage basin.

(2) Total surface area of the drainage basin (hectares).

(3) Length of tertiary basin channel (km).

(4) Type and location (UTM coordinates) of hydrologic structures not recorded in Data Tables 4 or 5.

D. Format

1. Factor Overlay (figure A7)

a. The general format for the factor overlay will be as described in section A-1 of this appendix.

b. Source(s) used in the preparation of the factor overlay and tables will be entered in section B (figures A1 and A2) to the left of the coverage diagram when they are not adequately described in the coverage diagram. Where a single source is used, or all sources apply to the entire sheet, the coverage diagram may be replaced by the source listing.

2. Data Tables (figure A8)

a. The general format of the data tables will be as prescribed in section A-1 of this appendix.

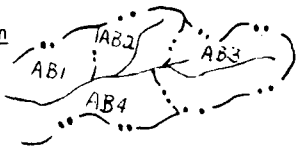
b. Where the number of entries will permit, the Drainage Basin Data Tables will be placed on a single overlay. When the amount of information is too great to permit placing all tables on a single overlay, a separate overlay will be prepared for each table.

E. Symbolization. The following symbology will be used on the factor overlay.

1. Drainage basin boundary lines

These boundary lines mark the topographic location where precipitation divides to flow to one drainage basin or another.

2. Drainage basin identification



a. The first letter identifies the primary drainage basin.

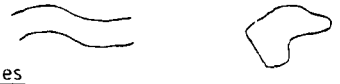
b. The second letter identifies the secondary drainage basin.

c. The number identifies the tertiary drainage basin.

3. Watercourse and water body shore alinement

a. Watercourses with gap widths of 50 m or less are symbolized with a single line.

b. Watercourses with gap widths greater than 50 m and all water body shorelines are drawn to scale.



F. Data Tables

1. Data Table 4 - Primary Drainage Basins

Data appearing in this table will be referenced to primary drainage basins identified on the overlay.

a. Column 1; ID. Record the letter assigned to each primary drainage basin, e.g. A, B, C, etc.

b. Column 2; Name. Record the name of the primary watercourse in this column.

c. Column 3; Political Unit(s). Record the name of the political unit(s) encompassing the drainage basin.

d. Column 4; Basin Area. Determine the area of each primary drainage basin. Record this value to the nearest 0.1 hectare.

e. Column 5; Channel Length. Determine the length of the channel. Record this value to the nearest 0.1 km.

f. Column 6; Hydrologic Structures (Type). Record the type of hydrologic structures, e.g. concrete dam, earthen dam, lock, etc.

g. Column 7; Hydrologic Structures (UTM coordinates). Determine the UTM coordinates (± 10m) of the hydrologic structures. Record the coordinates in this column.

h. Column 8; No. of Secondary Drainage Basins. Record the number of secondary basins which lie within the primary basin.

i. Column 9; No. of Tertiary Drainage Basins. Record the number of tertiary basins which lie within the primary basin.

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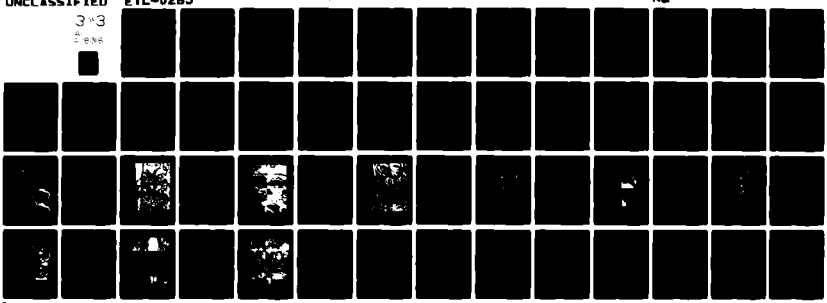

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2. Data Table 5 - Secondary Drainage Basins

Data appearing in this table will be referenced to secondary drainage basins identified on the overlay.

a. Column 1; ID. Record the letters assigned to each secondary drainage basin, e.g. AB, AE, AG, etc.

b. Column 2; Name. Record the name of the secondary watercourse in this column.

c. Column 3; Basin Area. Determine the area of each secondary drainage basin. Record this value to the nearest 0.1 hectare.

d. Column 4; Channel Length. Determine the length of the channel. Record this value to the nearest 0.1 km.

e. Column 5 and 6. Hydrologic Structures (Type and UTM coordinates). Record the type and UTM coordinates (± 10m) of hydrologic structures not recorded in Data Table 4.

3. Data Table 6 - Tertiary Drainage Basins

Data appearing in this table will be referenced to tertiary drainage basins identified on the overlay.

a. Column 1; ID. Record the alphanumeric characters assigned to each tertiary drainage basin, e.g. AB 1, AB 2, AB 3, etc.

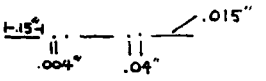
b. Column 2; Name. Record the name of the tertiary watercourse in this column.

c. Column 3; Basin Area. Determine the area of each tertiary drainage basin. Record this value to the nearest 0.1 hectare.

d. Column 4; Channel Length. Determine the length of the main channel. Record this value to the nearest 0.1 km.

e. Column 5 and 6; Hydrologic Structures (Type and UTM coordinates). Record the type and UTM coordinates (± 10m) of hydrologic structures not recorded in Data Table 5.

Symbolization

Feature	Symbol	Dimensions
Drainage Basin Boundary Line		
Drainage Basin Identification	AA1	AA1 =10"
Watercourse Alinement		

A-4. Ground Water

A. Introduction

1. This section prescribes the format and symbols to be used to prepare factor overlays for the data field ground water.

2. It is not anticipated that all data required by these specifications will be available during the initial preparation of a factor overlay. The factor overlay concept envisions the systematic recording of data as it is acquired, periodic revision of the overlays, and the accumulation of data over a period of time.

B. General Description

The ground water factor overlay will consist of two parts as follows:

1. An overlay registered to a 1:50,000 scale map (figures A9 and A10).

2. Two accompanying data tables describing those features assigned ID numbers on the overlay as well as other related information (figure A11).

C. Data Elements

The following data elements will be presented by the factor overlay and accompanying tables:

1. Factor Overlay

   a. Location of wells and springs.

   b. Location of observation wells.

   c. Location of water quality sample sites.

   d. Contour map of ground water surface (if sufficient number of ground water levels are known).

2. Data Tables

   a. Data Table 7 - Wells and Springs

      (1) ID numbers and UTM coordinates of all wells, springs, and water quality sample sites.

      (2) Yield (gpm) of wells and springs and date measured.

      (3) Specific capacity (gpm/ft drawdown) of wells.

      (4) Well dimensions and depths of water.

      (5) Water quality information.

      (6) Remarks.

   b. Data Table 8 - Observation Wells

      (1) ID numbers and UTM coordinates of all observation wells.

      (2) Well dimensions.

      (3) Depth to water table information.

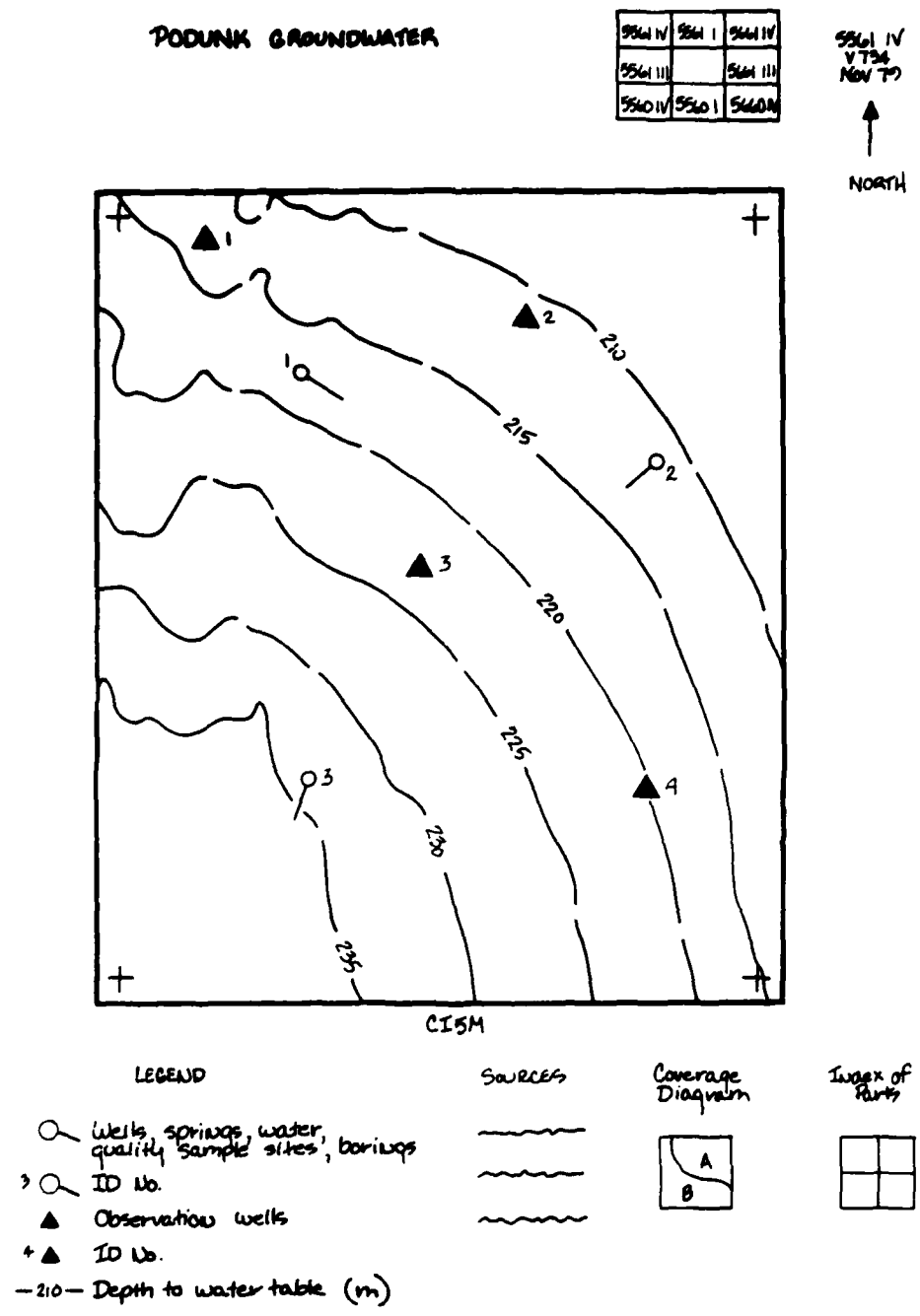
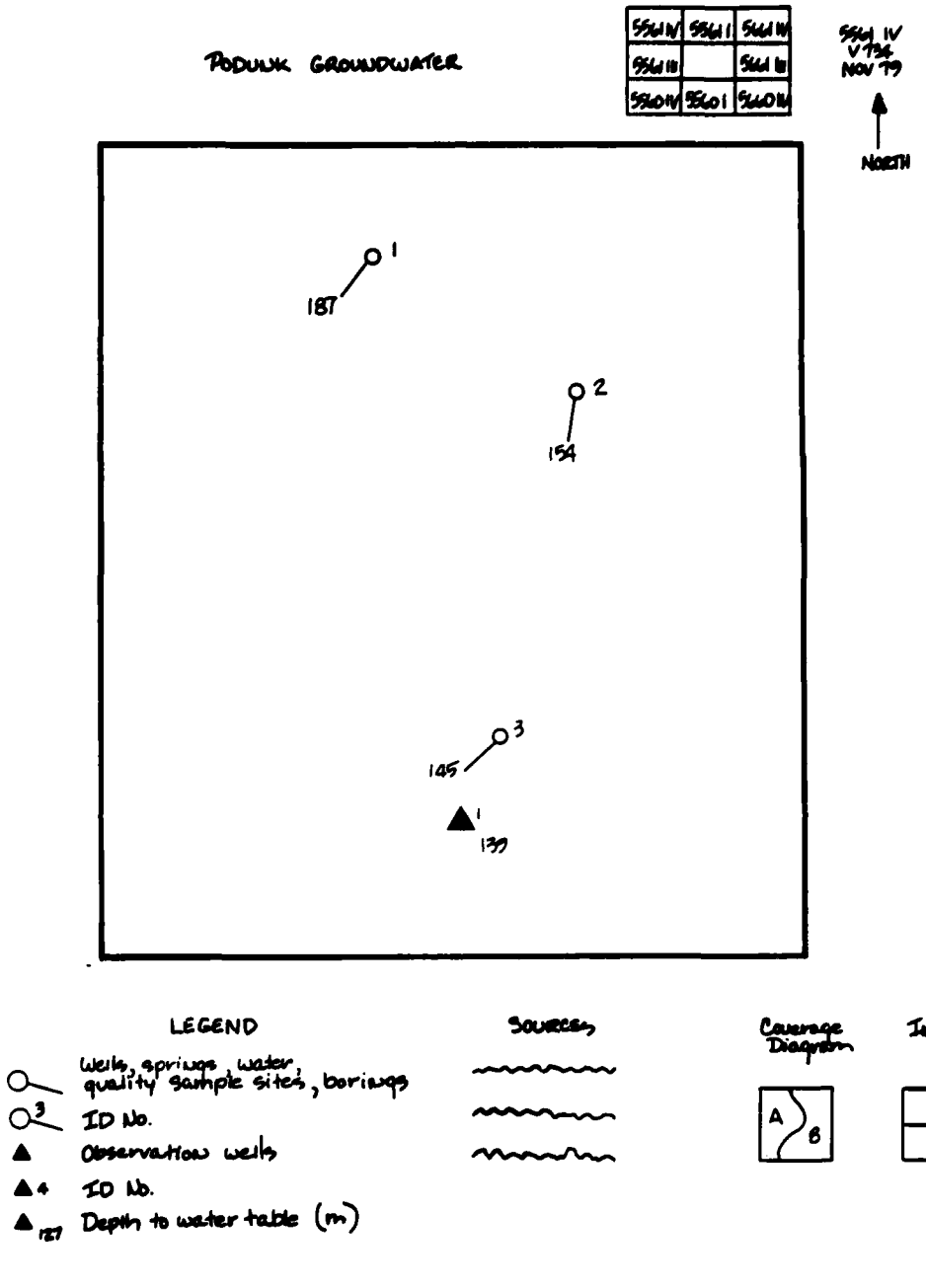


Figure A9. Format for Ground Water Factor Overlay.



Note. This format is used when there is an insufficient number of known ground water levels to construct a contour map.

Figure A10. Alternate Format for Ground Water Factor Overlay.

DATA TABLE 7 - WELLS AND SPRINGS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ID No	Type	Name	UTM Coordinates	Yield (gpm)	Date Measured	Specific Capacity (gpm/ft drawdown)	Diameter (cm)	Well Depth (m)	Depth to water (m)	Land Surface Datum above Mean Sea Level (m)	Top of Well above lsd (m)	Water Quality					Remarks
												Component	Units	Min	Max	Mean	
1	Spring	Unnamed	36504271	72	3/75	N/A	—	—	—	—	—	Temp Ca Mg pH Nitrate Dissolved Solids	°C mg/L mg/L units mg/L mg/L	14 48 3 7.0 0.1 148	18 384 175 7.8 15 1948	16 63 12 7.5 0.7 862	Flows yearround except during driest years.
2	Well	Unnamed	36504934	90	Estimated	Unknown	15	118	52	69.7	1.3	No data					Source of irrigation water
3	Well	Unnamed	36514827	—	—	—	15	227	—	—	—	Temp Iron Mn CO_3 Nitrate	°C mg/L mg/L mg/L mg/L	— — — — —	— — — — —	16 580 210 0 .23	Water quality sample site

DATA TABLE 8 - OBSERVATION WELLS

1	2	3	4	5	6	7	8	9	10	11
ID No	UTM Coordinates	Diameter (cm)	Well Depth (m)	Highest (m)	Date	Lowest (m)	Date	Mean (m)	Land Surface Datum above Mean Sea Level (m)	Top of Well above lsd (m)
1	36504265	8	192	2.3	3/75	10.5	9/64	6.2	230	1.2
2	36504295	15	70	3.1	4/70	11.2	10/71	7.6	202	0.9

Figure A11. Format for Ground Water Data Tables.

(4) Land surface datum (lsd) above mean sea level (msl).

(5) Top of well above land surface datum (lsd).

D. Format

1. Factor Overlay (figures A9 and A10)

a. The general format for the factor overlay will be as described in section A-1 of this appendix.

b. Source(s) used in the preparation of the factor overlay and tables will be entered in section B (figures A1 and A2) to the left of the coverage diagram when they are not adequately described in the coverage diagram. Where a single source is used, or all sources apply to the entire sheet, the coverage diagram may be replaced by the source listing.

2. Data Tables (figure A11)

a. The general format of the data tables will be as prescribed in section A-1 of this appendix.

b. Where the number of entries will permit, the Ground Water Data Tables will be placed on a single overlay. When the amount of information is too great to permit placing both tables on a single overlay, a separate overlay will be prepared for each table.

E. Symbolization

The following symbology will be used on the factor overlay.

1. Wells, springs, water quality sample sites, borings.

a. The symbol marks the location of features noted above.

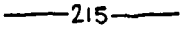
b. The ID number serves as a cross reference to Data Table 7.

2. Observation Wells

a. The symbol marks the location of observation wells.

b. The ID number serves as a cross reference to Data Table 8.

3. Depth to Water Table



Number indicates the estimated depth to water table in meters.

F. Data Tables

1. Data Table 7 - Wells and Springs

Data appearing in this table will be referenced to wells, springs, water quality sample sites, and borings identified on the overlay.

a. Column 1; ID number. Record the identification number assigned to each feature in this column.

b. Column 2; Type. Record the type of feature in this column e.g. well, spring, boring, etc.

c. Column 3; Name. Record the name of the feature, if known, in this column.

d. Column 4; UTM Coordinates. Determine the UTM coordinates (±10m) of each feature. Record the coordinates in this column.

e. Column 5; Yield. Record the yield in gallons per minute (gpm) in this column.

f. Column 6; Date Measured. Record the month and year the yield was measured,e.g. 4/75, 8/80, etc.

g. Column 7; Specific Capacity. Record the specific capacity (gpm per ft drawdown) in this column.

h. Columns 8 and 9; Well Diameter and Depth. Record well diameter to the nearest centimeter (cm) and well depth to the nearest meter (m) in columns 8 and 9 respectively.

i. Column 10; Depth to Water. Record the depth to water to the nearest 0.1 meter (m) in this column. Also record the date the measurement was taken, if any.

j. Column 11; Land Surface Datum above Mean Sea Level. Record the land surface datum (lsd) above mean sea level (msl) to the nearest meter. This is the elevation of the local topography above mean sea level.

k. Column 12; Top of Well above LSD. Record the distance to the nearest 0.1 meter (m) that the top of the well extends above the land surface datum.

l. Columns 13 and 14; Water Quality Component and Units. Record the water quality component,e.g. nitrate, dissolved solids, etc. in column 13. Record the unit of measure,e.g. °C, mg/l, etc. in column 14. For the purposes of this guide, mg/l may be taken to be equivalent to parts per million (ppm).

m. Columns 15 - 17; Min, Max and Mean. Record the minimum, maximum and mean values for each water quality component in columns 15, 16, and 17 respectively.

n. Column 18; Remarks. Record pertinent descriptive information concerning each well and spring in this column.

2. Data Table 8 - Observation Wells

Data appearing in this table will be referenced to observation wells identified on the overlay.

a. Column 1; ID number. Record the identification number assigned to each observation well in this column.

b. Column 2; UTM Coordinates. Determine the UTM coordinates (± 10m) of each observation well. Record the coordinates in this column.

c. Columns 3 and 4; Well Diameter and Depth. Record well diameter to the nearest centimeter (cm) and well depth to the nearest meter (m) in columns 3 and 4 respectively.

d. Columns 5 and 6; Highest and Date. Record the highest water table level to the nearest 0.1 meter (m) and the date (month/year) of occurrence in columns 5 and 6 respectively.

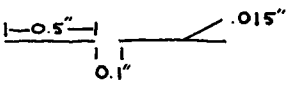
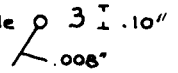
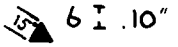
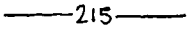
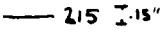
e. Columns 7 and 8; Lowest and Date. Record the lowest water table level to the nearest 0.1 meter (m) and the date (month/year) of occurrence in columns 7 and 8 respectively.

f. Column 9; Mean. Record the mean depth to water table to the nearest 0.1 meter (m) in this column.

g. Column 10; Land Surface Datum above Mean Sea Level. Record the land surface datum (lsd) above mean sea level (msl) to the nearest meter (m). This is the elevation of the local topography above mean sea level.

h. Column 11; Top of Well above LSD. Record the distance to the nearest 0.1 meter (m) that the top of the well extends above the land surface datum.

Symbolization

Feature	Symbol	Dimensions
Water Table Contour Lines		
Wells, Springs, Borings, Water Quality Sample Sites		.10" dia. circle 
Observation Wells		
Depth to Water Table		

APPENDIX B. LOCATION OF SOURCES

B-1. Literature and Map Sources

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Agency Affiliation: National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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Reference: (301)495-2404; 2405; 2406; IDS 179
Interlibrary loan: (301)495-2404; 2405; 2406; IDS 179

Services:
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Circulation: To agency personnel and other government and non-government libraries.
Interlibrary loan: Requests accepted on ALA/ILC form, by letter, telephone and teletype; both books and periodicals are available. All outside requests must be made through a library.

Resources:
Size of collection: 175,000 volumes; 1,300 periodical subscriptions.
Major subjects: meteorology; hydrology; climatology.
Publications: List of periodicals (available); List of accessions (available).

BUREAU OF RECLAMATION LIBRARY

Denver Federal Center, Building 67, Denver, Colorado 80225.

Librarian: Paul F. Mulloney

Agency Affiliation: U.S. Department of the Interior

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Telephone:
Office: (303) 234-3019
Reference: (303) 234-3019
Interlibrary (303) 234-3019

Services:
Reference: no restrictions
Reading room and stacks: no restrictions
Circulation: no restrictions
Interlibrary loans: requests accepted in any form. Periodicals do not circulate outside the Bureau. If only source, periodical articles will be xeroxed on a limited basis.

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* Federal Library Resources. A User's Guide to Research Collections, Science Associates/International, Inc. 1973.

Resources:
Size of collection: 29,000 volumes; 747 periodical subscriptions
Major subjects: water resources and all related subjects such as dams, irrigation, reservoirs, structural engineering, desalination, environment,engineering, canals, earthquakes, rock mechanics, hydrology, power transmission, management, computers.
Publications: List of periodicals (available only in house); List of accessions (available only in house)

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Director: Walter B. Greenwood

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Office: 433-2386 IDS 158; Autovon 288 (Code 11)
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Resources:
Size of collection: 150,000 volumes; 300 periodical subscriptions
Major subjects: naval and general history, cruises, exploring expeditions with emphasis on pole exploration, economic and political theories and conditions, geography, travel and guide books, international law and diplomacy, warfare with emphasis on naval and combined operations, naval architecture and ship-building, naval customs and traditions, naval education, schools and training, naval hospitals and medical service, naval pay, allowances and pensions, naval regulations, orders and instructions, naval reserve, naval shore stations, yards and bases, navigation, hydrography, shiphandling, Navy music, cook books, rations and equipment, astronomy and mathematics as they relate to navigation, aviation, civil affairs and military government communications and signals, courts (martial, courts of inquiry, justice and punishment), leadership, personnel selection, management and public administration, morale services, sports, recreation, ordnance, gunnery, piracy, privateering, suppression of slave trade, uniforms, insignia awards, medals and flags, U.S. Coast Guard, U.S. Marine Corps.
Publications: List of accessions (available)

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Corps of Engineers, Sacramento, California

Geological Survey, Department of Interior

Bureau of Reclamation, Department of Interior

Public Health Service, Department of Health, Education and Welfare

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Agriculture Research Service, Department of Agriculture

Soil Conservation Service, Department of Agriculture

Defense Mapping Agency Hydrographic/Topographic Center
6500 Brookes Lane
Washington, D.C. 20335

Provides accurate charts and related information for foreign waters

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National Technical Information Service
Springfield, Virginia 22162

Distributes U.S. Geological Survey Water Data Reports

US Coast Guard (GSBR)
400 Seventh St., SW
WASH DC 20590

Distributes Bridges Over Navigable Waters of the United States

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National Ocean Survey (NOS)
Distribution Division (C44)
6501 Lafayette Ave.
Riverdale, MD 20840

Distributes Navigation Charts, Coast Pilots, Tide Tables, Tidal Current Tables, Tidal Current Diagrams

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Defense Intelligence Agency
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U.S. Army Engineer Division, Middle East
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Huntington, WV

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Juneau, Alaska
Phone: 586-5319

Arizona, Bureau of Mines
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Idaho, Bureau of Mines and Geology
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Geological Survey Building
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Kansas Geological Survey
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Lawrence, Kansas
Phone: UNiversity 4-3101

Kansas Water Resources Board
1134-S State Office Bldg.
Topeka, Kansas 66612

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Director and State Geologist
College of Arts and Sciences
University of Kentucky
120 Graham Avenue
Lexington, Kentucky
Phone: 252-2200

Louisiana Geological Survey
State Geologist
Box 8847
University Station
Baton Rouge, Louisiana

Maine Geological Survey
State Geologist
Dept. of Economic Development
State House
Augusta, Maine
Phone: MAyfair 3-4511

Maryland, Dept. of Geology
Mines and Water Resources
Director
The Johns Hopkins University
Baltimore, Maryland
Phone: BElmont 5-0771

Michigan, Geological Survey Division
Division Chief
Department of Conservation
Stevens T. Mason Bldg.
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Phone: IVanhoe 5-8144

Minnesota Geological Survey
Director
University of Minnesota
Minneapolis, Minnesota
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Mississippi Geological Survey
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Missouri Geological Survey and
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Survey of Mineral Resources
State House Annex
Concord, New Hampshire
Phone: 225-6611

New Jersey Geological Survey
State Geologist
520 East State Street
Trenton, New Jersey
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New Mexico, Bureau of Mines and
Mineral Resources
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Campus Station
Socorro, New Mexico
Phone: 588

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Albany, New York

North Carolina Division of Mineral
Resources
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Dept. of Conservation and
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Grand Forks, North Dakota
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University Station, Box X
Austin, Texas
Phone: GReenwood 1-1534

Utah Geological and Mineralogical Survey
State Geologist and Director
103 Civil Engineering Bldg.
University of Utah
Salt Lake City, Utah
Phone: 322-6831

Vermont Geological Survey
State Geologist
Fleming Museum
University of Vermont
Burlington, Vermont
Phone: UNiversity 4-4511

Virginia Division of Mineral Resources
Commissioner of Mineral Resources and State Geologist
McCormick Road
P.O. Box 3667
Charlottesville, Virginia
Phone: 293-5121

Washington Division of Mines & Geology
Supervisor
335 General Administration Bldg.
Olympia, Washington
Phone: 753-6183

West Virginia Geological and Economic Survey
Director and State Geologist
Box 879
Morgantown, West Virginia
Phone: LInden 9-4461 and 9-4462

Wisconsin Geological and Natural History Survey
State Geologist and Director
Science Hall, University of Wisconsin
Madison, Wisconsin
Phone: ALpine 5-3311

Wyoming Geological Survey
State Geologist
Geology Bldg., Univ. of Wyoming
Laramie, Wyoming
Mail: Box 3008
University Station
Laramie, Wyoming
Phone: 745-3129

(Massachusetts. Hawaii, and Alaska do not have State geological surveys)

In addition to the geological surveys listed above, many States have a water resources institute, water commissioner, water engineer, State engineer, State health department, or planning commissions which collect water data.

SOCIETIES & ORGANIZATIONS

American Society of Civil Engineers

American Geophysical Union

National Water Well Association

Missouri Water Well Drillers Assoc.

National Research Council

River Basin Commissions

Water Resources Council

American Water Resources Association

B-2. Aerial Imagery Sources

U.S. GOVERNMENT AGENCIES

Aerial Photography Field Office
Agricultural Stabilization and Conservation Service
Department of Agriculture
Western Laboratory
2222 West 2300 South
P.O. Box 30010
Salt Lake City, UT 84125
(Source for all states)

Defense Intelligency Agency
ATTN: DIAAP-10
Washington, D.C. 20301

DMAHTC
6500 Brooks Lane
Washington, D.C. 20315

Bureau of Land Management
Department of Interior
Washington, D.C. 20240

Cartographic Archives Division
National Archives (GSA)
Washington, D.C. 20408

EROS Data Center
U.S. Geological Survey
Sioux Falls, SD 57198

National Cartographic Information Center (Headquarters)
Geological Survey
Department of Interior
Reston, VA 22090

NCIC-Mid-Continent
USGS, 1400 Independence Rd.
Rolla, MO 65401

NCIC-Rocky Mountain
USGS, Topographic Division
Stop 510, Box 25046
Denver Federal Center
Denver, Colorado 80225

NCIC-Western
USGS, 345 Middlefield Rd.
Menlo Park, CA 94025

National Ocean Survey
Department of Commerce
Washington Science Center
Rockville, MD 20852

Soil Conservation Service
Department of Agriculture
Federal Center Building
East-West Highway and Belcrest Rd.
Hyattsville, MD 20781

Tennessee Valley Authority
Maps and Surveys Branch
210 Haney Building
Chattanooga, TN 37401

Eastern US Forest Service Photography
Chief Forest Service
U.S. Department of Agriculture
Washington, D.C. 20250

Western US Forest Service Photography
Region

1	Federal Building, Missoula, MT 59801
2	Federal Center, Building 85, Denver, CO 80025
3	Federal Building, 517 Gold Ave. SW Albuquerque, NM 87101
4	Forest Service Building, Ogden, UT 84403
5	630 Sansome St., San Francisco, CA 94111
6	P.O. Box 8623, Portland, OR 97208
10	Regional Forester, U.S. Forest Service, P.O. Box 1628, Juneau, AK 99801

COMMERCIAL FIRMS

Aerial Data Service
10338 East 21st Street
Tulsa, OK 74129

Aero Service Corporation
4219 Van Kirk Street
Philadelphia, PA 19135

Air Photographics Inc.
P.O. Box 786
Purcellville, VA 23132

Alster and Associates, Inc.
6135 Kansas Avenue, NE
Washington, D.C. 20011

Ammann International Base Map &
Air Photo Library
223 Tenth Street
San Antonio, TX 78215

Burlington Northern Inc.
650 Central Building
Seattle, WA 98104

Cartwright Aerial Surveys Inc.
Executive Airport
6151 Freeport Boulevard
Sacramento, CA 95822

H. G. Chickering, Jr.
Consulting Photogrammetrist, Inc.
P.O. Box 2767
1190 West 7th Avenue
Eugene, OR 97402

Fairchild Aeromaps Inc.
14437 North 73rd Street
Scottsdale, AZ 85254

Grumman Ecosystems Corp.
Bethpage, NY 11714

Henderson Aerial Surveys Inc.
5125 West Broad Street
Columbus, OH 43228

Walker and Associates Inc.
310 Prefontaine Building
Seattle, WA 98104

Western Aerial Contractors, Inc.
Mahlon Sweet Airport
Route 1, Box 740
Eugene, OR 97401

L. Robert Kimball
615 West Highland Ave
Ebensburg, PA 15931

Lockwood, Kessler & Bartlett, Inc.
One Aerial Way
Syosset, NY 11791

Mark Hurd Aerial Surveys, Inc.
345 Pennsylvania Avenue South
Minneapolis, MN 55426

Merrick and Company
Consulting Engineers
2700 West Evans
Denver, CO 80219

Murry - McCormick
Aerial Surveys Inc.
6220 24th Street
Sacramento, CA 95822

Photographic Interpretation Corp.
Box 868
Hanover, NH 03755

Quinn and Associates
460 Caredean Drive
Horsham, PA 13044

Sanborn Map Company, Inc.
P.O. Box 61
629 Fifth Avenue
Pelham, NY 10803

The Sidwell Company
Sidwell Park
28W240 North Avenue
West Chicago, IL 60185

Surdex Corporation
25 Mercury Boulevard
Chesterfield, MO 63017

Teledyne Geotronics
725 East Third Street
Long Beach, CA 90812

United Aerial Mapping
5411 Jackwood Drive
San Antonio, TX 78238

CANADA

National Air Photo Library
Surveys and Mapping Building
615 Booth St.
Ottawa, Canada K1A 0E9

B-3. Ground Imagery Sources

U.S. Army Imagery Interpretation Group
Bldg. 213, Washington Navy Yard
Washington, D.C.

Defense Intelligence Agency
ATTN: RPP-3
Washington, D.C. 20301

U.S. Army DARCOM Service Support Activity
Audio-Visual Presentations Division
Room 1C13, Pentagon
Washington, D.C. 20310

APPENDIX C. REFERENCE MATERIALS

C-1. Nautical Charts - provide information on navigation channels and navigation aids; provide vertical clearances of bridges and overhead cables in feet above mean high water; provide horizontal clearances of bridges (see figure C1).

Source: Corps of Engineer Div/Dist
National Ocean Survey

C-2. United States Coast Pilots - supplement navigational information shown on nautical charts and are based upon field inspections; information relates to navigation on U.S. coastal and intracoastal waters, and waters of the Great Lakes; include outstanding landmarks, channel peculiarities, ice, weather, etc.; horizontal clearances are given when they are less than 50 ft.

Source: National Ocean Survey

C-3. Tide Tables - include predicted times and heights of high and low waters for every day in the year for a number of reference stations; also include differences for obtaining similar predictions for other locations.

Source: National Ocean Survey

C-4. Light Lists - describes aids to navigation, consisting of lights, fog signals, buoys, light-ships, day beacons, and electronic aids.

Source: Superintendent of Documents
Washington, D.C.

C-5. Bridges Over Navigable Waters of the United States - a four part directory of bridges across the navigable waters of the United States include bridge locations, name of owner and navigation clearances (see figure C2).

Source: U.S. Coast Guard

C-6. Federal Project Reports - contain detailed information, including typical cross section of structures and channels at federal project locations (see figure C3).

Source: Corps of Engineer Div/Dist

C-7. U.S. Geological Survey Water - Data Reports - consist of records of stage, discharge, water quality of streams and springs; stage, contents, and water quality of lakes and reservoirs; water levels and water quality of wells.

Source: National Technical Information Service

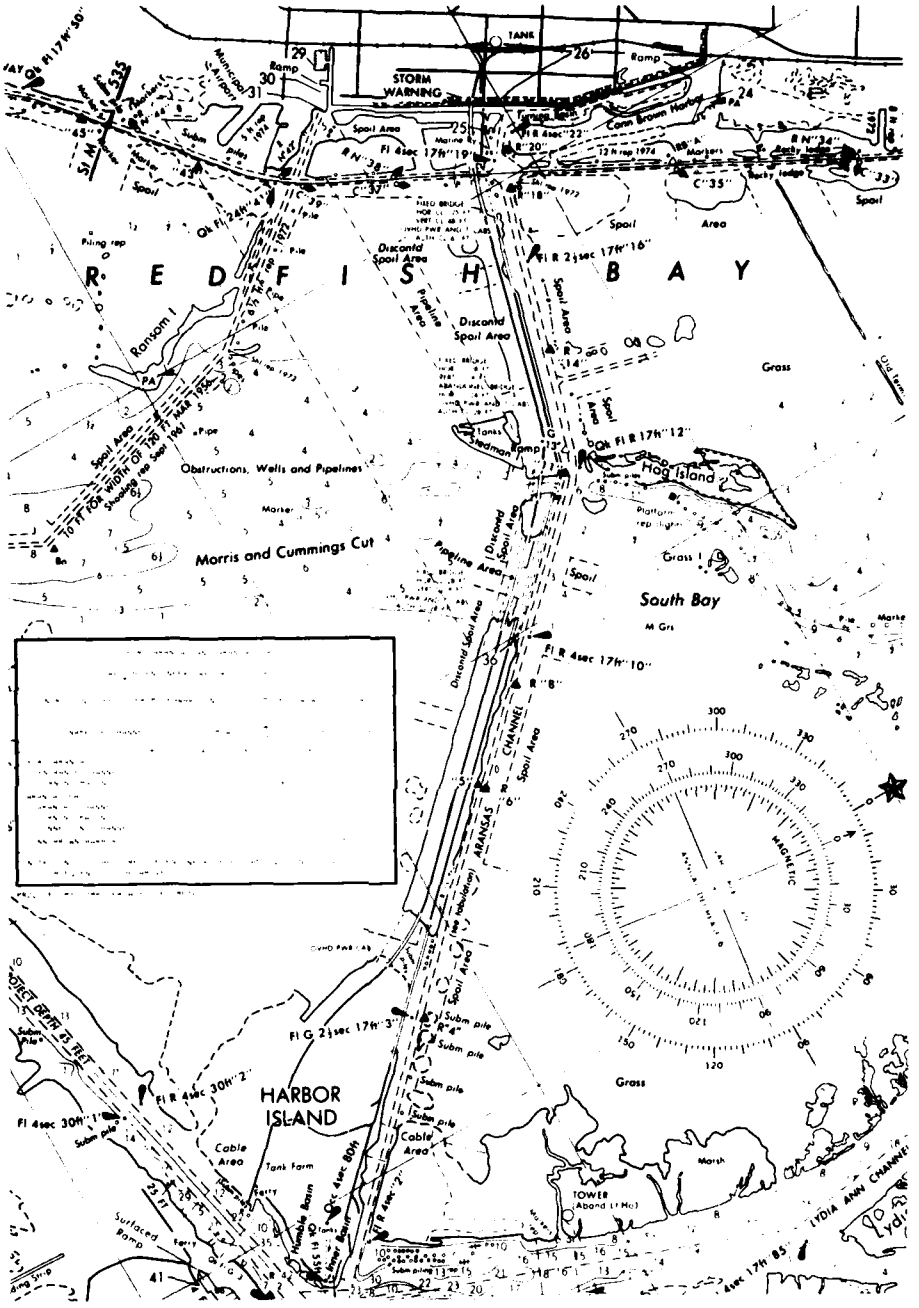

Figure C1. Data From Nautical Chart 11314 Intracoastal Waterway Carlos Bay to Redfish Bay.

Copy available to DTIC does not permit fully legible reproduction

Miles Above Mouth	BRIDGE AND LOCATION - OWNER	TYPE	CLEARANCES Horz	Vertical LW	Vertical HW	Traffic	DATE Permit/Completed	
	ABSECON CREEK							
3.0	Absecon N J US 30 New Jersey	F	50	6	3	Hwy	2-63	10-64
3.1	Absecon N J Penn Reading Seashore Lines	F	31	25	22	RR	6-39	3-40
3.2	Absecon N J SH 43 New Jersey	F	56	6	2	Hwy		
3.7	Absecon N J US 9 New Jersey	F	19	7	4	Hwy	4-54	11-54
	ABSECON INLET							
0.6	Atlantic City N J SH 87 New Jersey	B	75	15	11	Hwy	4-24	
0.6	Atlantic City N J SH 87 New Jersey	F	100	64	60	HWY	8-67	
	ACADEMY COVE							
0.0	Wickford R I Rhode Island	F	18	5	1	Hwy	3-52	
	ACUSHNET RIVER							
0.0	New Bedford Mass US Commonwealth of Massachusetts	SW	95	10	6	Hwy	3-01	
0.9	New Bedford Fairhaven Mass US 6 Commonwealth of Massachusetts	F	62		8	Hwy	11-72	
1.0	New Bedford Mass New Bedford	F	62	11	8	Hwy		6-63
2.2	New Bedford Mass New Bedford	F			6	Hwy		
	AINGER CREEK (Formerly Oyster Creek)							
0.2	Grove City Fla SH 775 Florida	F	13	7	6	Hwy	11-26	6-27
0.7	Grove City Fla SH 776 Florida	F	NA'	NA'	NA'	Hwy		1965

' *Not Available*

Figure C2. Data From Bridges Over Navigable Waters of the United States (Part 1).

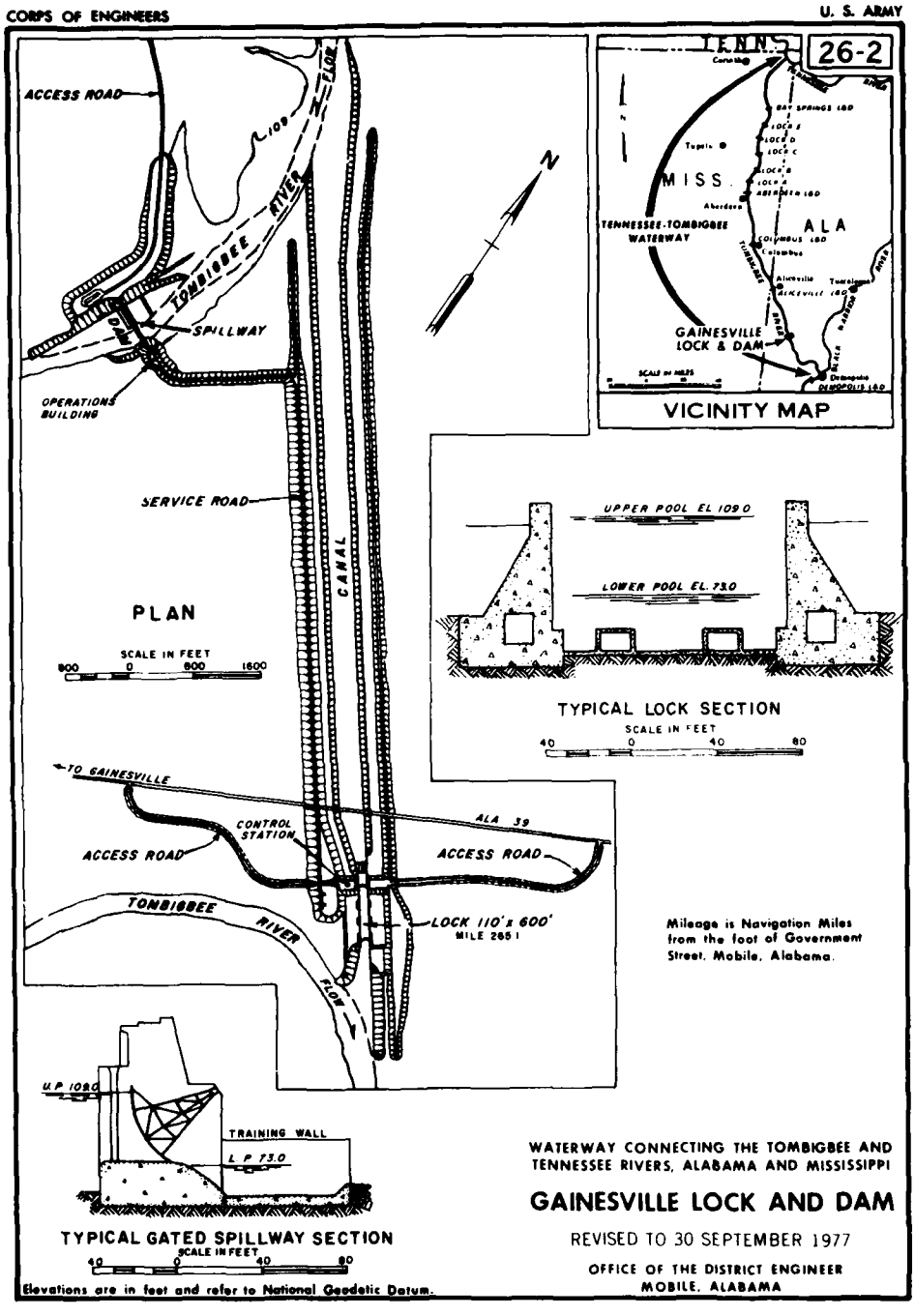

Figure C3. Data From Gainesville Lock and Dam Federal Project Report.

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APPENDIX D. STEREOGRAMS

STEREOGRAM No. 1 BRYANT POND

Keywords:	water quality	Film	Super XX	f = 12 inches
	water body	Filter	Minus-blue	H = 9,600 ft.
		Camera	Unknown	RF = 1:13,000*
				b = 0.220 ft. (left)
				0.226 ft. (right)

A manufacturing facility of Allied Paper Company at Kalamazoo, Michigan, (A.8-2.3) and its chemical waste disposal area are shown. Bryant Pond is at C.8-3.8 and the treatment plants are at C.21-2.44 and C.40-2.80. Indications of a counter clockwise circulation within the pond are visible. The pond outlet is just out of the stereogram at what would be E.01-4.02. Note the difference in tone between Bryant Pond and the water body at A.6-1.8.

Source of Photography: University of Illinois Stereogram Series

*RF value computed after photo reduction

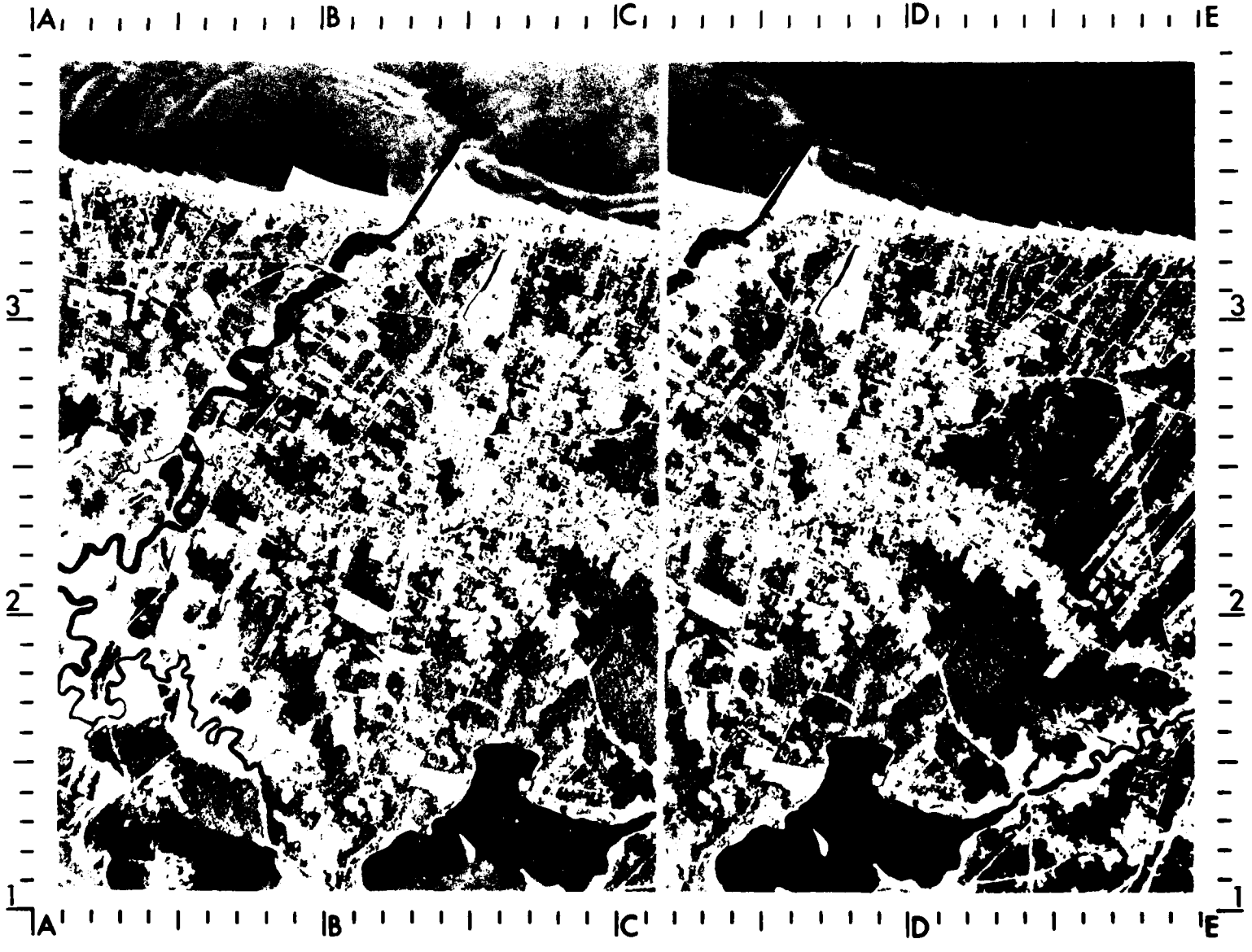
E
3
2
1
E
D
D
C
C
B
B
A
A
3
2
1

STEREOGRAM No. 2 SWAN POND

Keywords:	wet area (marsh)	Film	Panchromatic	f = 153.02mm
	water body	Filter	Minus-blue	H = 12,600 ft.
	pier	Camera	Unknown	RF = 1:25,150
	jetty			b = 0.323 ft.

An area along the southern coast of Cape Cod is shown. The large pond at A.6-1.0 is drained by an extremely meandering, small watercourse which appears to traverse a marshy area. Near A.6-1.6 this watercourse passes through a former lake which has been filled with vegetation. A series of piers and jetties have been built along the coastline to protect the beach from erosion. Longer piers near B.3-3.4 protect the small-boat channel at the mouth of the meandering watercourse cited earlier. The dark tone and straight sides of this channel suggest that it is periodically dredged. A series of light-toned underwater sand ridges (B.2-3.8) are present to the left of the small boat channel.

Source of Photography: University of Illinois Stereogram Series


A
B
C
D
E
1
2
3

STEREOGRAM No. 3 ROCK SPRING BRANCH

Keywords:				
dam	Film	Super XX	f = 12 inches	
water body	Filter	Minus-blue	H = 4,700 ft.	
watercourse alinement	Camera	K-17B	RF = 1:4,700	
			b = 0.324 ft.	

Minor tributaries and gullies similar to those that form the headwaters of nearly all watershed drainage systems are visible in the vicinity of B.7-3.8. A small earth dam built across Rock Springs Branch at C.3-2.1 has created a pond of characteristic dark tone. A spillway is visible on the dam at B.25-2.05.

Source of Photography: University of Illinois Stereogram Series

A
B
C
4
3
2
1

STEREOGRAM No. 4 LOCK AND DAM

Keywords:	lock	Film	Dupont 136R	f = 6.0 inches
	levee	Filter	Yellow	H = 4,800 ft.
	ice	Camera	Wild RC 8	RF = 1:9,600
	pumping station			b = 0.291 ft.
	dam			

The Illinois river channel is shown bounded by steep buffs above and a levee below. The pumping station at C.5-1.5 takes the collected drainage from the old flood plain and pumps it into the river below the dam. Note the ice of light tone which has collected behind the dam. The lock is located at the upper end of the dam near B.2-2.1.

Source of Photography: University of Illinois Stereogram Series

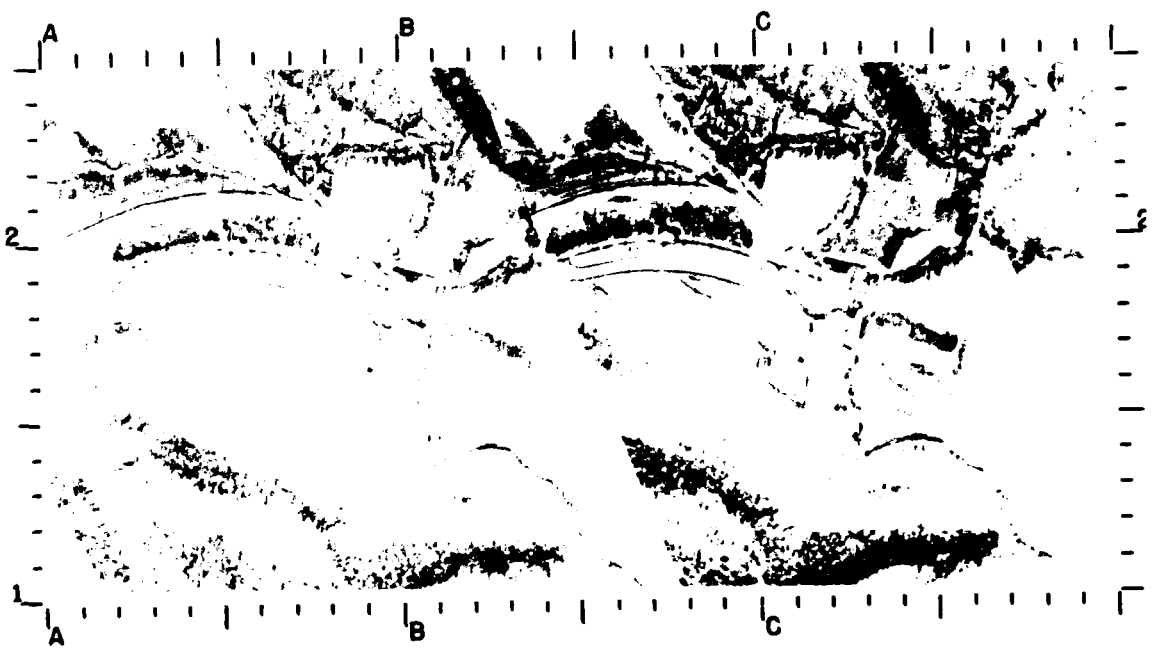
A
B
C
4
3
2
1

STEREOGRAM No. 5 MORGAN SCHOOL

Keywords:	watercourse	Film	Super XX	f = 12 inches
	alinement	Filter	Minus-blue	H = 14,500 ft.
	drainage canal	Camera	K-17B	RF = 1:14,500
				b = 0.387 ft.

Natural and man-made drainage channels in an area of wind-deposited soils are shown. The oriented (regular) channels are visible as at A.0-2.0 to A.75-2.10. This channel and others contrast with the irregular, somewhat meandering, natural stream.

Source of Photography: University of Illinois Stereogram Series


A
B
C
2
1
A
B
C

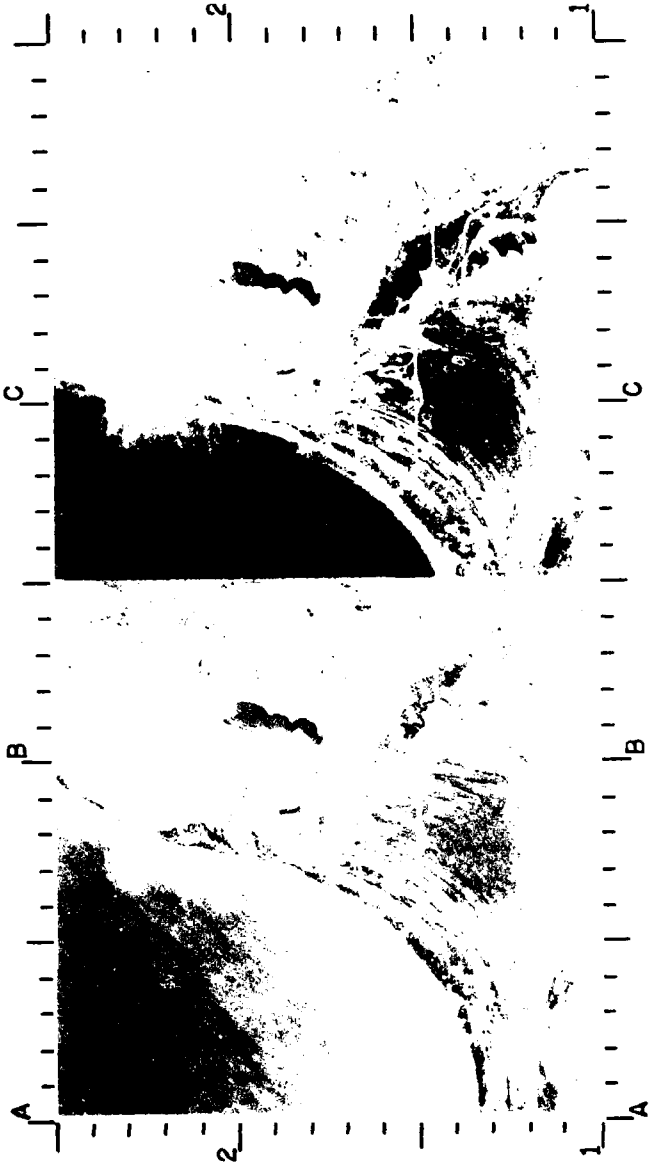
STEREOGRAM No. 6 PROSPECT HILL

Keywords:	wet area (peat bog, cranberry bog) water body	Film	Panchromatic	f = 6 inches
		Filter	Minus-blue	H = 30,450 ft.
				RF = 1:71,000*
				b = 0.286 ft.

A series of beach ridges between Glen Lake (bottom) and Lake Michigan (upper left) control the meandering path of Crystal River. At B.1-1.9 a natural depression, probably a peat bog, is occupied by a poor stand of northern white cedars. The limits of the depression are clearly marked by a fringe of balsam-fir that completely surround the area. At A.35-1.10 a small cranberry bog is visible, although the indications of cultivation are not visible at this scale.

Source of Photography: University of Illinois Stereogram Series

*RF value computed after photo reduction

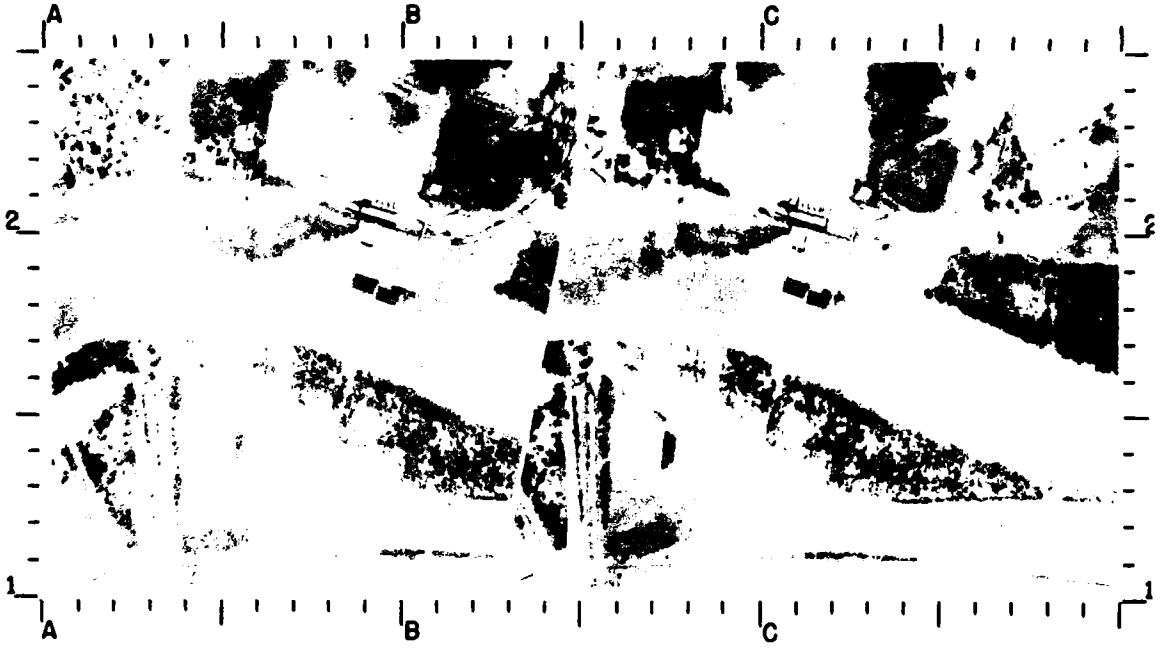

2
1
C
C
B
B
A
A
2
1

STEREOGRAM No. 7 TEN DOLPHINS

Key words:	special feature (dolphins)	Film	Super XX	f = 6 inches
	levee	Filter	Minus-blue	H = 7,920 ft.
	drainage ditch	Camera	K-17B	RF = 1:15,840
				b = 0.197 ft.

The Central Illinois Power Company thermal electric power plant on the Illinois River is shown. A string of dolphins in the river serve as a barge landing and seven coal barges can be seen at the landing. The coolant water discharge point (C.31-1.90) is marked by a light-toned trail of effluent coolant water leading downstream from the entry point. There are several levees, one of which extends from A.35-1.65 to B.30-1.25. Also depicted are several drainage ditches, one of which extends from A.35-1.05 to B.25-1.10.

Source of Photography: University of Illinois Stereogram Series


A
B
C
2
1
A
B
C

STEREOGRAM No. 8 SPILLWAY

Keywords:				
	dam	Film	Super XX	f = 12 inches
	ice	Filter	Minus-blue	H = 9,600 ft.
		Camera		RF = 1:11,200*
				b = 0.269 ft.

A large thermal electric plant on the Kalamazoo River is shown. A small dam is visible on the river at A.25-1.33. Ice can be seen on the water surface behind the dam. An indentation in the ice (A.45-1.80) reveals the location of the discharge point of heated coolant water from the plant. A streak of slightly lighter tone than the surrounding water leads from this entry point to the dam spillway. This difference in tone corresponds to the flow pattern of the effluent coolant water.

Source of Photography: University of Illinois Stereogram Series

*RF value computed after photo reduction

2
1
C
B
A
C
B
A
2
1

STEREOGRAM No. 9 OHIO RIVER LOCK AND DAM

Keywords:				
	dam	Film	Super XX	f = 209.79mm
	lock	Filter	Minus-blue	H = 14,425 ft.
	levee	Camera	Unknown	RF = 1:21,000
				b = 0.295 ft.(left)
				0.280 ft.(right)

Ohio River Lock and Dam No. 51 are shown. An earthen levee surrounds the village located on the upper bank of the Ohio. The lock is located at the upper end of Dam No. 51.

Source of Photography: University of Illinois Stereogram Series

STEREOGRAM No. 10 BIGHORN RIVER

Keywords:	irrigation canal	Film	Panchromatic	f = 8.25 inches
	watercourse	Filter	Minus-blue	H = 17,200 ft.
		Camera	Unknown	RF = 1:25,000
				b = 0.210 ft.

A meandering mature river in a semi-arid environment is shown. The extensively cultivated alluvial terrace below the river is provided water for irrigation through a canal network. Note the linearity of the canal system when compared with the natural drainage channels.

Source of Photography: University of Illinois Stereogram Series

APPENDIX E. GLOSSARY

E-1. Watercourses and Water Bodies

aqueduct - A large pipe or conduit made for transporting water from a distant source.

artifical flood - Any inundation brought about in whole or in part by the deliberate breaching of dams or levees, manipulation of water control structures, or temporary damming operations.

backwater - Water held or forced back in consequence of some obstruction, such as a dam, regulator, or constricted channel section.

bank - The continuous sloping margin of a stream or other water body; on a stream, designated left or right bank as it would appear to an observer facing downstream.

bar - An accumulation of alluvial material in a stream channel, commonly emergent at low water.

bed - The bottom on which a body of water rests.

canal - A channel or waterway artificially constructed or maintained for conveying water, or for connecting two or more bodies of water.

channel - (1) The trench in which a stream normally flows; (2) that part of a body of water deep enough to be navigable.

channel cross section - A representation of a channel as it would appear if cut through cross-wise and vertically at right angles to its long axis, and depicting, specifically, the area of the channel through which flow has passed or is supposed to pass.

channel rectification - A process by which various hydraulic works and construction methods are used for channel improvement purposes, the object being to arrange such works so that the current is utilized to the greatest extent possible to move the bed material, and so to produce the desired channel conditions.

channel roughness - Roughness of the channel, including extra roughness due to local expansion or contraction and obstacles, as well as roughness of the stream bed proper, i.e., friction offered to the flow by the surface of the bed of the channel in contact with the water; expressed by the roughness coefficient of the velocity formulae.

channel storage - Water stored temporarily in the channel when flow is greater than the immediate discharge capacity of the channel.

conduit - An artifical or natural channel which carries water for either supply or industrial purposes.

climatology - The study of climate, including statistical relations, mean values, normals, frequencies, variations, and distribution of meteorologic elements.

critical depth - The depth of water in which a given discharge flows in a given channel with a minimum content of specific energy.

critical flow - A condition of flow in which fluid is flowing in a canal at the critical depth.

current velocity - The speed, expressed in units of time and distance, at which water flows in a stream, channel, or conduit.

design flood - Flood data utilized in controlling the design of a specific dam or other structure.

dike - (1) A bank, as of earth, thrown up as a barrier to inundation; a levee; (2) a bank of earth thrown up from a ditch.

discharge - A volume of water which flows past a cross section of a stream, channel, or conduit in a unit of time; also called rate of flow.

discharge measurement - The process of determining the discharge of a stream through actual measurement and consisting of measurements of depth, width, and current velocity at various points in the stream cross section.

discharge rating curve - A graphic representation expressing the relation between discharge and stage at a given point. Also called a discharge curve; rating curve; stage-discharge relation.

diversion - Changing the course of a stream or diverting any part of its flow in another direction.

divide - A line which follows the highest ground between stream or drainage systems.

drainage - The process of removing surface water or ground water by artificial or natural means.

drainage basin - The entire area from which a lake or stream and its tributaries receives water. Also called a catchment basin, river basin, drainage area, watershed.

Drainage Canal/Ditch - an artifical waterway used for drainage of surface water.

dredging - The process of scooping up or removing earth, sand, silt, etc., for the purpose of deepening or widening stream or harbor channels.

dry gap width - The distance between right and left banks determined at the first slope break above mean water level.

duration curve - A graphic representation used to present the relation between flow and time, or precipitation and time.

flood peak - Maximum rate of flow occurring during a flood.

flood plain - The area along a stream that is subject to inundation when the stream overflows its banks. Sediment carried by the water is deposited on the flood plain.

flood wall - A work or structure raised to some height and intended for defense or security against floods.

floodway - A channel constructed to carry flood water in excess of the amount that can be safely carried in a stream even when the stream's capacity has been increased by the construction of levees; such a channel is usually constructed with levees on each side, parallel and adjacent to the stream, and sufficiently long to carry the flood waters around the restricted section of the stream.

flow - A quantity of water carried by a stream or conduit, expressed in volume per unit of time.

flow regulation - The control of the flow of water by hydraulic structures.

flume - An open and inclined channel, usually V-shaped, which carries water at a constant gradient. It is used in mining, logging and irrigation operations.

ford - A site in a stream or other water body that can be waded by man or traversed by a car, truck, or tank. The water body at a ford is shallow, and has a low velocity and a firm, level, and not too bouldery bottom.

freeboard - The vertical distance between the normal maximum operating level of a reservoir and the top of the dam, or between the stage of the design flood and the top of the levee.

frequency curve - A graphic representation which gives the number of times that a particular quantity, like intensity of rainfall or runoff, has occurred or may occur; sometimes frequencies are expressed as percentages of the total number of values available.

gage, automatic recording - A gage in which the stages of the stream are automatically recorded on strip charts or other forms, providing a continuous record of the variation in river stage and their times of occurrence. Sometimes referred to as a recording gage.

gage height - The height of water above a gage datum.

gage zero - Elevation of the zero of a gage above a certain datum.

gorge - A deep, narrow, steep-sided valley, commonly with a stream occupying most of its floor.

gradient - The longitudinal slope, obtained by dividing the difference in bed or water-surface elevations at two points on a watercourse by the distance between them.

high water - The highest water level within the period considered.

high water mark - A mark left by silt, debris, or other means at the highest point reached by water during a flood.

hydraulics - That branch of science, or of engineering, which treates water or other fluid in motion, its action in rivers and canals, the works and machinery for conducting or raising it, its use in driving machinery, etc.

hydrograph - A graph showing stage, discharge, velocity or other feature of flowing water with respect to time; for example, a discharge hydrograph shows the discharge of a stream as ordinate against time as abscissa.

hydrography - The science of measuring and studing oceans, seas, rivers and other waters and their marginal land areas, including fundamental elements needed for safe navigation of such areas.

hydrologic cycle - The general circulation of water in its various states, from the sea to the atmosphere, to the ground, and back to the sea.

hydrology - A science dealing with the occurrence of water on the earth; its physical and chemical properties, transformations, combinations and movements; especially with the course of water from the time of its precipitation on land until its discharge into the sea or return to the atmosphere.

inflow - Water flowing into a stream, lake, or reservoir.

Inland Sea - A extensive body of water confined to the interior of a country or region.

irrigation canal/ditch - An artificial waterway used for transporting water.

isohyet - A line connecting points of equal rainfall. A rainfall contour map is called an isohyetal map.

lagoon - A shallow sound or channel of salt water separated from the open sea by sand or an offshore reef.

levee - an embankment along a stream or other water body, built for the purpose of limiting floods.

lock - An enclosure in a canal or river with gates at each end, used in raising or lowering boats as they pass from level to level.

low water - The lowest water level within the period considered.

marsh - A tract of spongy, wet, or water-covered treeless ground usually covered by grasses, cattails, or similar vegetation.

mass rainfall curve - A graph showing accumulated precipitation against time.

mean water - An arithmetic mean of daily mean water levels for a year, or the average of a number of years.

navigation canal - An artifical waterway improved by locks, levees, etc., to permit navigation.

normal - An average value which, in the course of years, any meteorologic element is found to have on a specified date or during a specified month or other portion of the year, or during the year as a whole; in hydrology, sometimes used for median, as in normal water level.

orifice - A hole or opening, usually in a plate, wall, or partition, through which water flows, generally for purposes of control measurement.

overbank - With reference to stream level, that stage at which the stream is no longer confined to its normal course of flow, spilling out into the adjacent areas.

outflow - The flow of water out of a stream or reservoir.

paddy/wet crops - An artifically flooded area such as a rice field.

penstock - A closed pipe or channel used by hydroelectric installation to carry water, under pressure, to the generating plant.

planimeter - An instrument for measuring the area of any plane figure by passing a tracer round the boundary line.

pond - A small area of still water, usually artifical.

pool elevation - The water surface elevation of a reservoir measured from mean sea level or a given datum.

profile - The bottom or water surface elevation of a stream plotted against distance.

pump - A device or machine that raises or transfers fluids by suction or pressure, or both.

rainfall excess - That part of the rain of a given storm which has an intensity of rainfall exceeding evaporation, absorption and infiltration capacity of the soil; that is, the volume of rainfall available for direct runoff.

rainfall intensity - The rate at which rainfall occurs, expressed in depth units per unit of time. Also called the rate of rainfall.

rapid(s) - A part of a stream with greater than normal current velocity and turbulence, but without actual waterfall; the stream has a higher gradient in this sector and generally flows through rocks or other obstructions.

reach - (1) The section of a stream between two gaging stations, or other significant points; (2) A straight portion of a stream.

reservoir - An area of water-storage often artifically created by building a dam at a suitable retaining point across a watercourse.

reservoir capacity - When applied to a reservoir, the capacity is the quantity of water stored between bed level and level of the spillway crest.

resistance - Those structures or factors that resist the flow of water.

runoff - That portion of the precipitation that is transmitted through natural surface channels; the residual of rainfall after the deduction of losses.

runoff depth - Total runoff from a drainage area or basin, divided by the area; expressed in either units of depth or units of volume per unit area of the basin.

salt pan - A basin surrounded by and lined with a solid deposit of salt.

snowfield - An accumulation of snow and ice which remains on the surface of the ground for a considerable period.

sounding - The depth of water in a stream, as measured from water surface to bed at one of several points.

spillway - A passage for spilling surplus water; a wasteway.

spillway gates - Gates of various types built on top of the spillway crest of a dam, and used to regulate the elevation of the water surface of the reservoir.

stage - (1) The height of the surface of a stream above an arbitrary point, such as the zero mark on a gage; also called gage height; (2) in popular usuage, bankfull stage refers to the depth of the stream when the water surface is at the top of the bank.

storage - The impounding of water in either surface or underground reservoirs for later use.

storm - A term commonly used for violent atmospheric disturbances, such as a gale, thunderstorm, rainstorm, or snowstorm.

stream - A general term for a body of flowing water. The term is usually applied to water flowing in a natural surface channel, but it may also be applied to water flowing in an open or closed conduit, and to a jet of water issuing from an opening.

stream pattern - An arrangement of stream parts, elements, or details that suggest a design or orderly distribution in natural or chance stream formations.

stream gage - A device for measuring the water surface level above a certain datum for record purposes.

swamp - A tract of wet or water-covered ground overgrown with trees and shrubs.

tailwater - The water just downstream from a structure.

tributary - A surface or underground stream which contributes its water, either continuously or intermittently, to another and larger stream.

turbidity - The approximate amount of suspended matter in water, expressed in parts per million.

unit hydrograph - A stream flow hydrograph of surface runoff resulting from one inch of excess rainfall falling during one unit of time over a specific drainage basin.

water body - An inland body of water which may or may not have a current or single direction of flow; e.g., a lake, reservoir, pond, etc.

watercourse - A stream, river, creek, brook, run, or canal, usually running in a definite channel or bed and discharging into another body of water.

watershed - The entire region that contributes water to a river or lake. Also called drainage basin, river basin, catchment area.

E-2. Ground Water

Anions - negatively charged ions of substances, commonly determined in chemical analyses of water, such as bicarbonate, carbonate, chloride, and sulfate ions.

Artesian - water rising above its level below ground when no longer confined, as by tapping with a well hole (see hydraulic head).

Aquiclude - a slightly permeable rock, soil, or zone which contains water but so severely impedes its passage that it rarely if ever is a source of water, although it may recharge aquifers or aquitards at a very slow rate over a long period of time (e.g., many clays).

Aquifer - any water-bearing horizon in soil or rock capable of yielding significant amounts of water; may be a stratigraphic unit, a layer or layers, a fracture zone, or other entity.

Aquifuge - an impermeable rock, soil, or zone which contains no water, or only trapped water, and forms essentially a total barrier to water movement (e.g., massive granite).

Aquitard - a rock, soil, or zone of low permeability which contains water but retards its passage to the extent that it is not normally considered an aquifer (e.g., certain silts).

Attitude - the inclination of an aquifer, such as a bed or fracture zone, or a gallery, in relation to the horizontal; the dip is the maximum angle of inclination and the bearing of that angle, and the strike is the bearing of a horizontal line within the aquifer.

Capillarity - the attractive force between two unlike molecules, measured by the amount of rise of water in glass tubes of hairlike diameters or in small interstices of laboratory samples.

Catchment area - the general area where water from rainfall and other sources enters the ground to feed an aquifer, or recharge it; often the site of outcrop of an aquifer.

Cations - positively charged ions of substances, commonly determined in chemical analyses of water, such as calcium, magnesium, potassium, and sodium ions.

Casing - tubing placed in a well during or after excavation to prevent the walls from caving and/or to prevent fluids from entering or leaving the hole.

Clarification - removal of suspended material, turbidity, and color by the addition of coagulation chemicals, thorough agitation and dispersal of chemicals, and complete flocculation and precipitation of the resulting large chemical flocs, which attract the suspended sediment and bacteria.

Color - includes apparent color with suspended matter present and true color with the suspended matter removed; quantitative standards are based on true color compared with colors produced by units of mg/l of platinum in water.

Cone of depression - the depressions, normally roughly conical, produced in a water table or piezometric surface by withdrawal of water, either by pumping or artesian flow; the three- dimensional measure of drawdown.

Contamination - impairment of the quality of water to a degree which creates an actual hazard to public health by toxic chemicals, radioactive isotopes, or pathogenic organisms.

Discharge - the rate of yield of water, or volume per unit time.

Drawdown - the lowering of the static level of a well caused by withdrawal of water either by pumping or artesian flow.

Ground Water province - an area of aquifers constituting a more or less closed system with common ground water characteristics, often recognized and identified by a proper geographic name; the ground water equivalent of the surface water drainage basin.

Hardness - power of water to neutralize soap attributable principally to calcium and magnesium salts and expressed as an equivalent concentration of calcium carbonate; includes both carbonate or temporary hardness (with CO_3 and OH scales forming upon evaporation or heating) and noncarbonate or permanent hardness (with SO_4 or CL scales).

Hydraulic head - artesian or piezometric pressure in a groundwater source, commonly measured as the height to which the water rises above its level of occurrence underground when no longer confined, as when tapped by a well hole.

Levels - as measured in a hydrographic record, from a gauge datum, represent depth variation rather than absolute depth, unless gauge zero is approximately at the land surface.

Mineralization - measure of the total dissolved solids in water.

Observation well - this is a borehole, cased or uncased, which is open in the saturated zone of an aquifer. An instrument suspended in the well records the fluctuation of water levels with time.

Outlet - any opening or nexus of openings at the surface of the ground through which ground water issues; if natural, a spring or seep (zone) of "leakage"), and if artificial, a well (vertical hole), gallery (horizontal hole, actually a variety of well), or open trench. A kanat is a unique type of gallery consisting of a nearly horizontal shallow dug tunnel with vertical air shafts leading to the surface and often of great lateral extent, characteristic of many areas in the near east.

Permeability - the capacity for transmitting a fluid, chiefly or exclusively through pores; if transmission is chiefly or exclusively through fractures, termed fracture permeability; generally expressed as a volume passing through a unit area in a unit time. A variant measure is hydraulic conductivity, numerically identical although a unit cross-sectional area of passage is assumed and lateral distance or area rather than volume is expressed.

Phreatohpytes - ground water indicators, plants whose roots tap water near, at, or below the water table.

pH - the negative reciprocal of the logarithm of hydrogen-ion concentration; loosely, acidity.

Piezometric surface - the inferred levels to which water in an aquifer under hydraulic head (which see) will rise if no longer confined, as when tapped by a well hole; the precise determination of this level at individual outlets (the static level) constitutes a "correction" or refinement of the more generalized piezometric level for a particular area.

Plug - a total obstruction placed at a certain level in a well to cut off water from lower sources (as to avoid saline influx) or to prevent aquifer contamination in an abandoned well.

Pollution - impairment of the quality of water by biological, chemical, physical, and radioactive substances to a degree which may not create an actual hazard to public health but which does adversely and unreasonably affect such water for some beneficial use; almost any substance becomes a pollutant if concentrated sufficiently.

Porosity - a measure of the proportion of a material consisting of pore space or voids.

Producing level - the water level in a well being pumped at a steady production rate; at non-production levels, referred to merely as a particular pumping level.

Pumps - the various types of well pumps and the lift heights of which they are capable are detailed in several references, particularly U.S. Department of the Army TM 5-297, Wells (1957) and TM 5-660, Water supply and treatment facilities (1952).

Pumpage inventory - a complete record of rate and total amount of pumping with time at a water point.

Recharge - the rate of replenishment of water in an aquifer; can be measured as volume per unit time like discharge.

Runoff - that portion of the precipitation which is discharged through natural surface channels. It includes direct runoff entering stream channels promptly after rainfall or snowmelt by flowing over the ground surface (surface runoff) or through the ground without becoming part of the ground water (sub-surface runoff); and base runoff entering stream channels as sustained or dry-weather flow contributed by effluent ground water or ground water runoff.

Safe yield - rate at which water can be withdrawn from an aquifer without depleting the supply to such an extent that withdrawal at this rate has an adverse effect on the aquifer or the quality of water.

Screen - a slotted or perforated cylindrical attachment to the bottom of the casing to prevent fine material from invading the casing, support the water-yielding formation, house a submersible pump adequately, and enhance development of a natural gravel residue pack.

Sedimentation - gravitational settling of suspended matter carried by water; usually accomplished by reducing velocity below a critical level.

Specific capacity - the discharge of a well per unit drop in water level (unit of drawdown).

Specific conductance - a measure of the ability of water and any other substance to conduct electricity (the reciprocal of resistance); specific for a unit distance over which the voltage drop is measured (e.g., one centimeter, at 25°C).

Specific retention - ratio, in percent, of the volume of water which a saturated sample will retain against the pull of gravity to its own volume.

Specific yield - ratio, in percent, of the volume of water which a saturated sample will yield by gravity to its own volume.

Spring - a natural flow of water from the earth's surface occurring where the watertable intersects the course.

Static level - the water level in a well when not being pumped; generally at or above the level at which the well hole first taps a saturated zone, but in some cases may be below that level.

Storage change - a variation in the amount of water impounded in surface or underground reservoirs, the latter including water contained in natural materials as either soil moisture or ground water.

Storage coefficient - volume of water released from storage in a unit volume, or unit vertical column of the aquifer when the water table or piezometric surface declines a unit distance; approximately equal to specific yield for nonartesian (gravity) aquifers.

Suspended solids - actual content of suspended materials obtained by direct measure (e.g., settling), in contrast to indirect measure by turbidity, which in some cases may overestimate or underestimate the actual particle content.

Transmissibility - the rate of flow of water (at prevailing temperatures) through a vertical strip of aquifer having a height equal to the thickness of the aquifer (and under a unit hydraulic gradient); generally expressed for a unit strip width. A variant measure is transmissivity, the numerical value for which is identical, although a unit strip width is assumed and lateral area rather than volume is expressed.

Turbidity - measured by the extent to which the intensity of light passing through water is reduced by suspended or colloidal matter; standard units are defined in terms of the depth of water to which a candle flame can be clearly distinguished.

Water balance - mathematical relationship of the components of the hydrologic cycle in which water continuously moves from the atmosphere to the earth and returns to the atmosphere; generally calculated over long periods of time for which the average annual precipitation generally is equal to the sum of the average annual water loss plus the average annual runoff; the balance may be significantly effected by short term storage changes.

Water-bearing structure/texture - any of a variety of rock and soil features that may serve as aquifers.

Water table - the upper surface of a zone of saturation in an unconfined aquifer; there may be several vertically discontinuous water tables in a particular area, and any minor water tables overlying a main water table extending more or less continuously to considerable depth are termed perched water tables.

Well - a deep hole or shaft sunk into the earth to tap an underground supply of water.

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